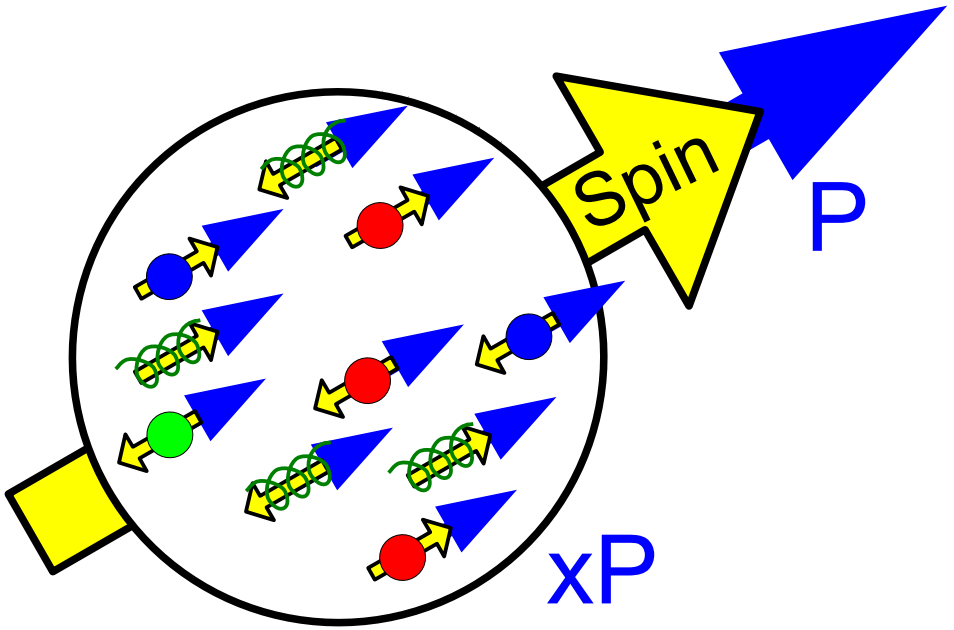
Forward upgrade for W physics at RHIC-PHENIX experiment

Apr. 29, 2009, DIS 2009

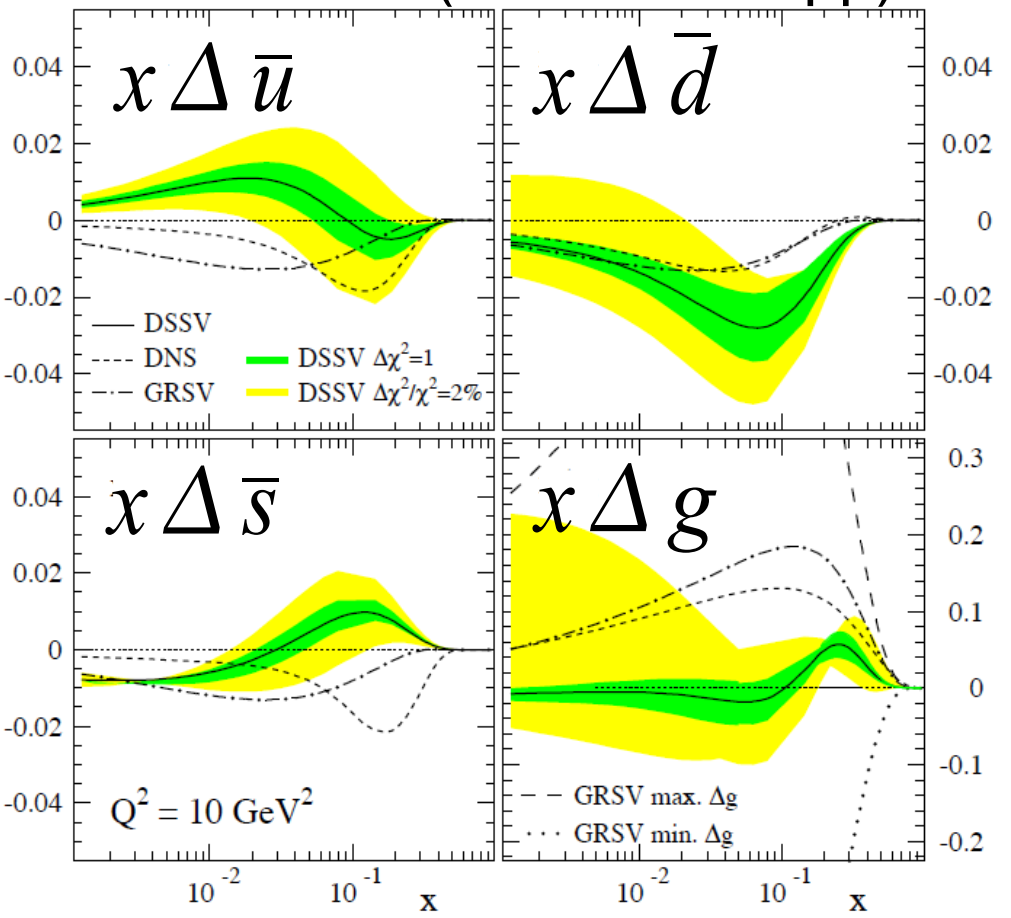
RIKEN
Yoshinori Fukao

Proton Spin Structure



Spin of parton is parallel or anti-parallel to proton?

DSSV2008 (DIS+SIDIS+pp)



$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L$$

ΔQ_v : Well known

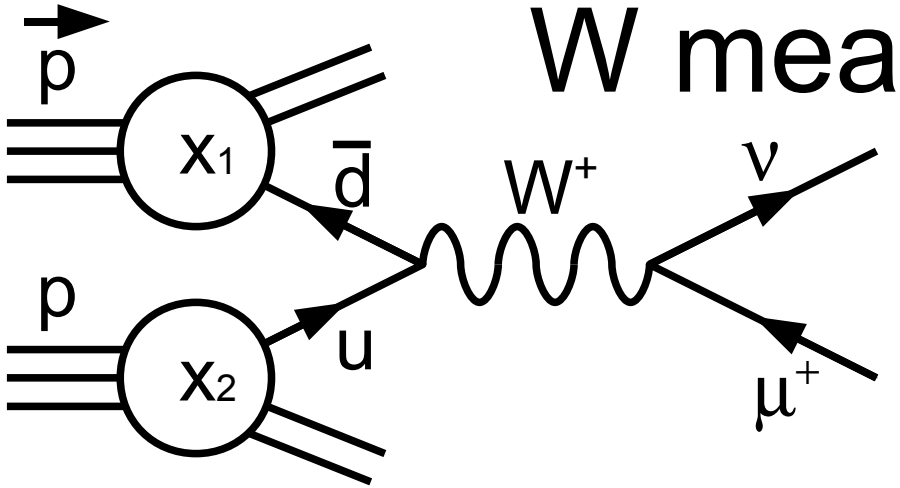
ΔG : Being revealed

$\Delta\bar{Q}$: **Less well-known**

L : Unknown

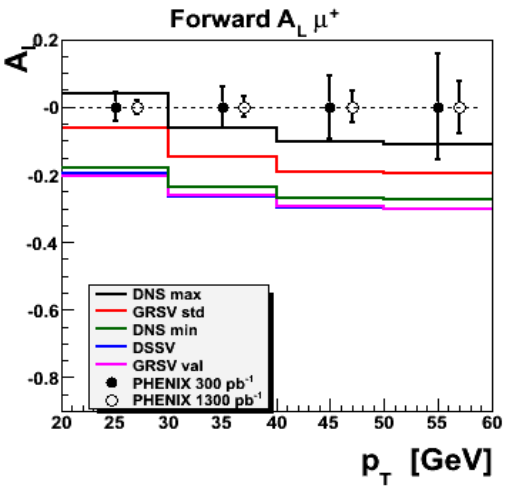
This talk focuses on sea quark, in particular about $\bar{u}$ $\bar{d}$ flavor separation by W measurement.

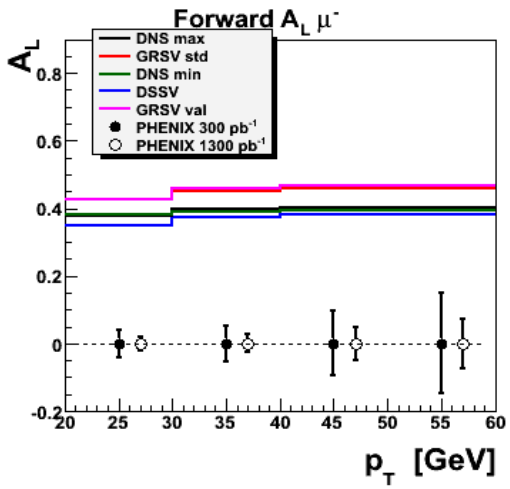
Sea Quark Polarization by W measurement

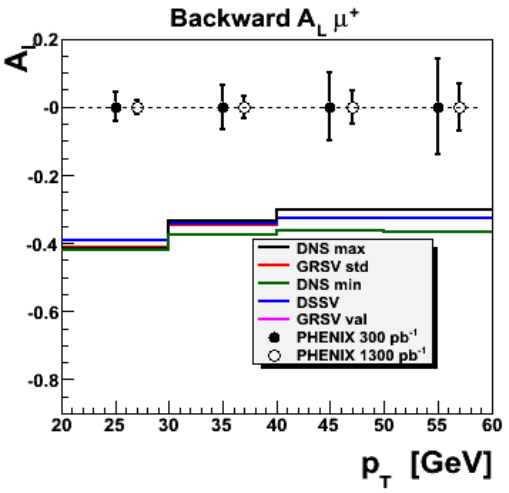


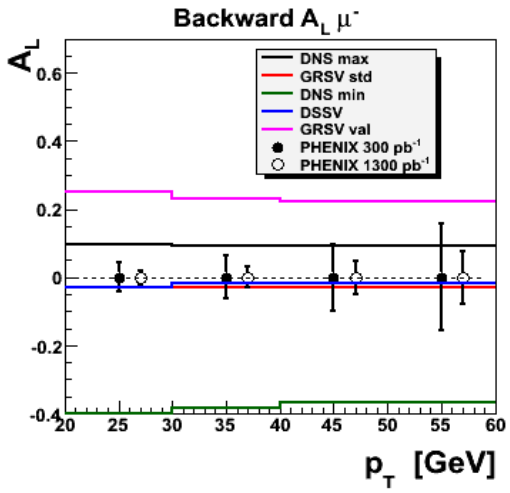
$$A_L^{W^+} = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} \sim \frac{\Delta u(x_1)\bar{d}(x_2) - \Delta \bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}$$

● 300 pb^{-1} ○ 1300 pb^{-1}









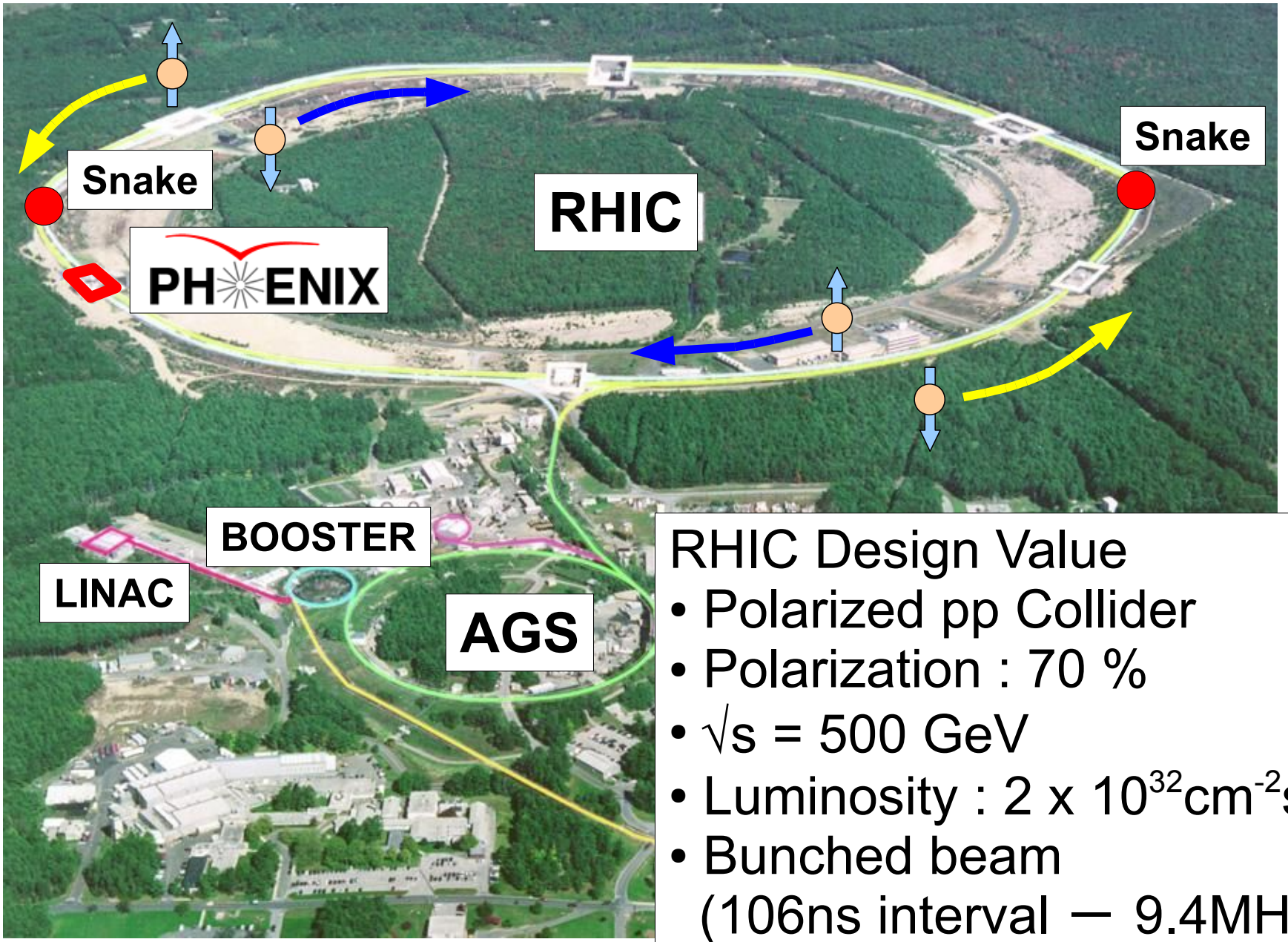
Feature of pp->W at RHIC

- u+$\bar{d}$ -> W^+, $\bar{u}$+d -> W^-
- q : helicity-, $\bar{q}$: helicity+
- No uncertainty from fragmentation function.
- But, low statistics

Talk by Todd Kempel on Monday

RHIC

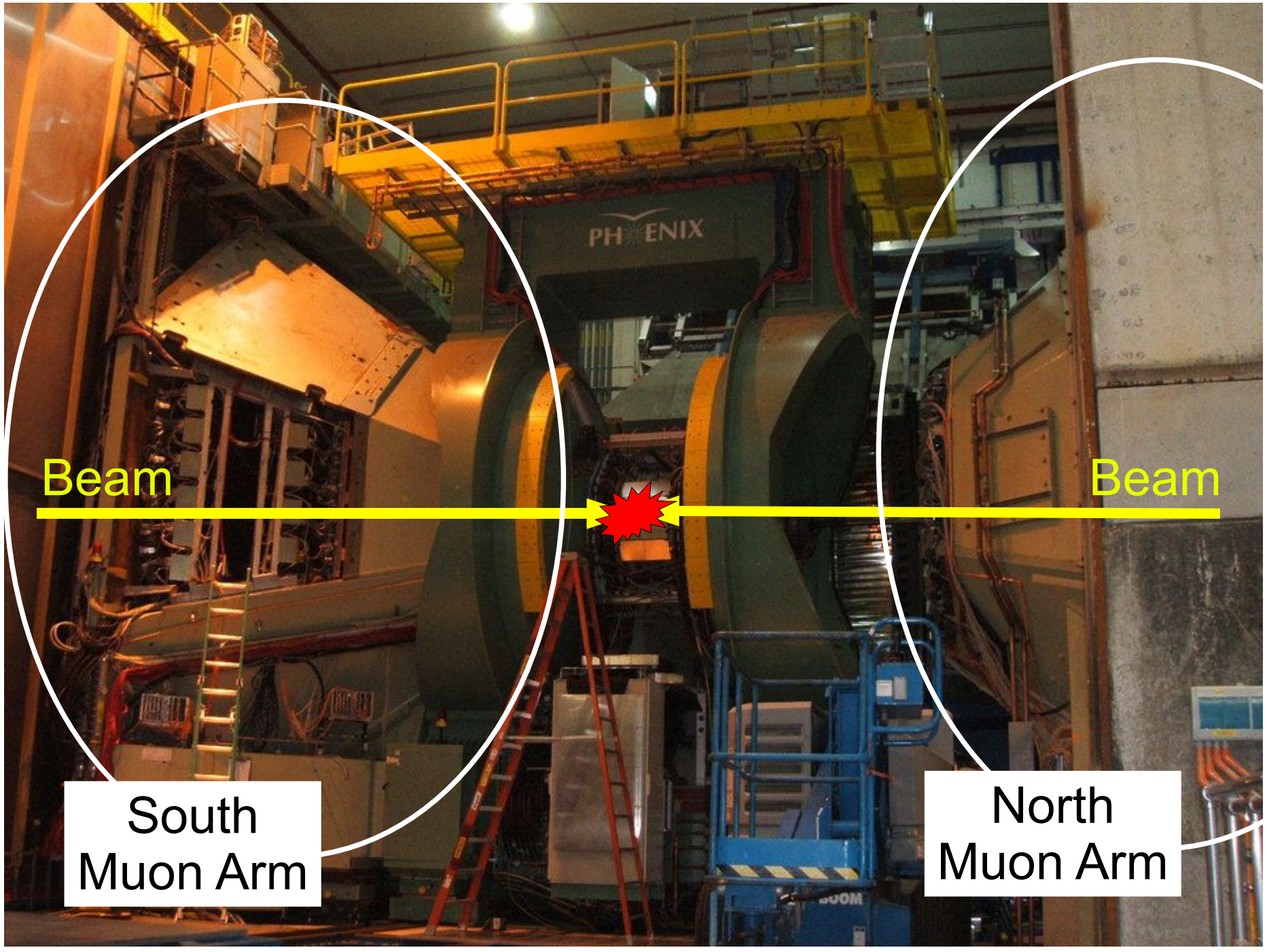
First physics run with 500GeV was operated in 2009.



RHIC Design Value

- Polarized pp Collider
- Polarization : 70 %
- $\sqrt{s}$ = 500 GeV
- Luminosity : 2 x $10^{32}cm^{-2}s^{-1}$
- Bunched beam
  (106ns interval — 9.4MHz)

PHENIX detector



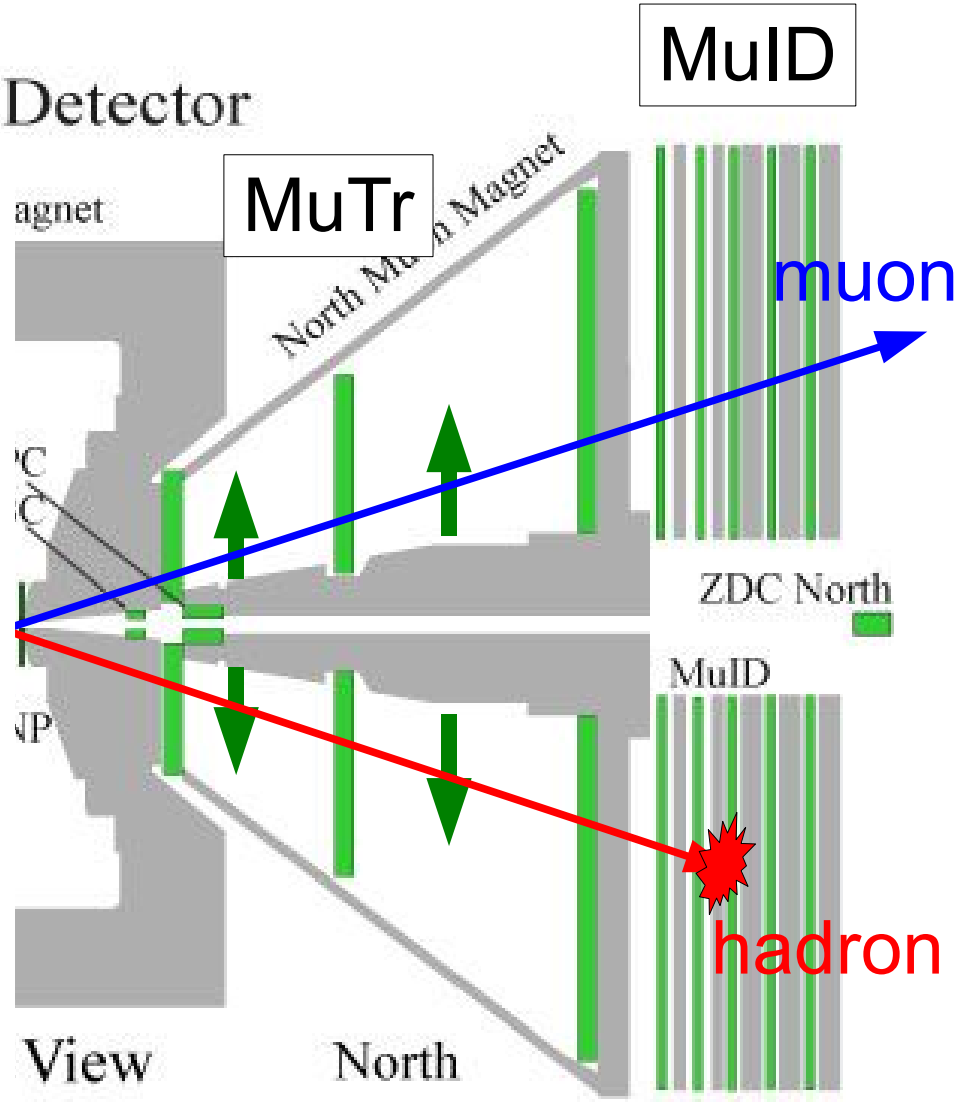
Current Muon Arm

Muon Tracking Chamber (MuTr)

- 3 stations of Cathode Strip Chambers
- 3 gaps + 3 gaps + 2 gaps
- Each gap has non-stereo plane, stereo-plane, and anode plane

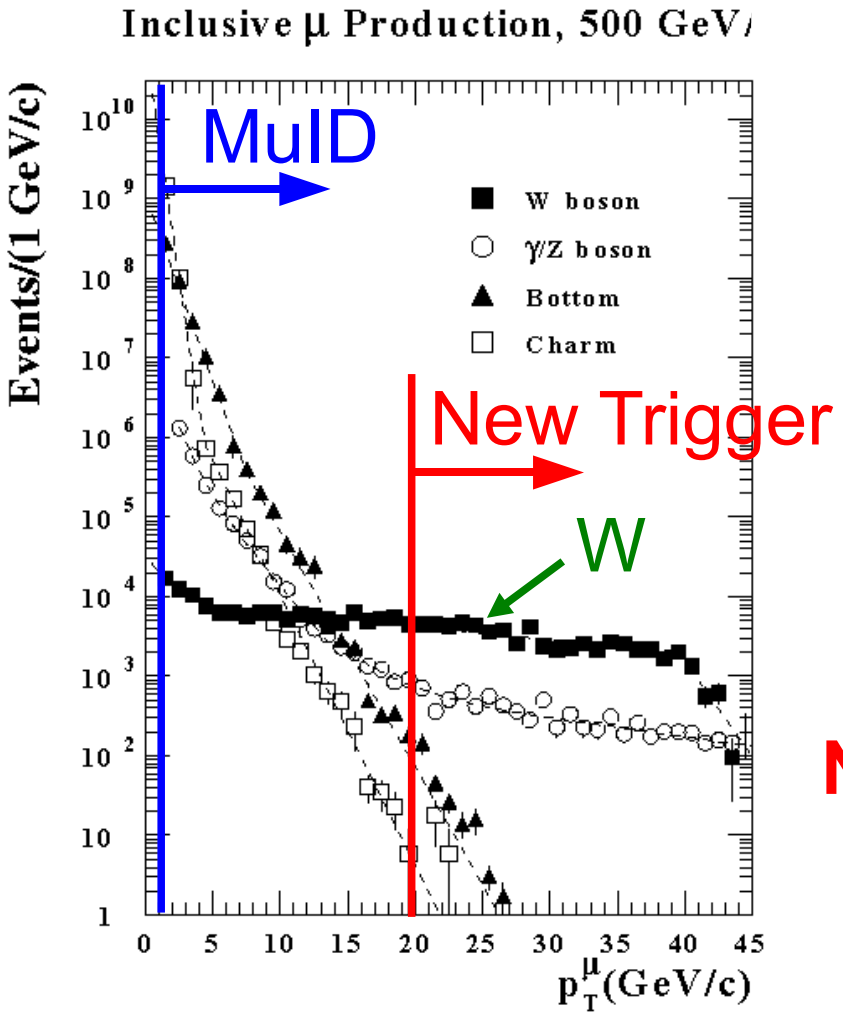
Muon Identifier (MuID)

- 5 layers of Iarocci tubes in x and y directions
- 80 cm of steel plate absorber (total)
- **Provides trigger p_{muon} > 1.5 GeV/c**



Trigger threshold by MuID is too low to collect W events.

Need of New W Trigger



Current MuID trigger

200kHz at 500GeV

↓

DAQ bandwidth for muon arm ~2kHz

↓

Additional rejection factor of 100 is required (RF~5000 for pp collision)

New Momentum Sensitive Trigger

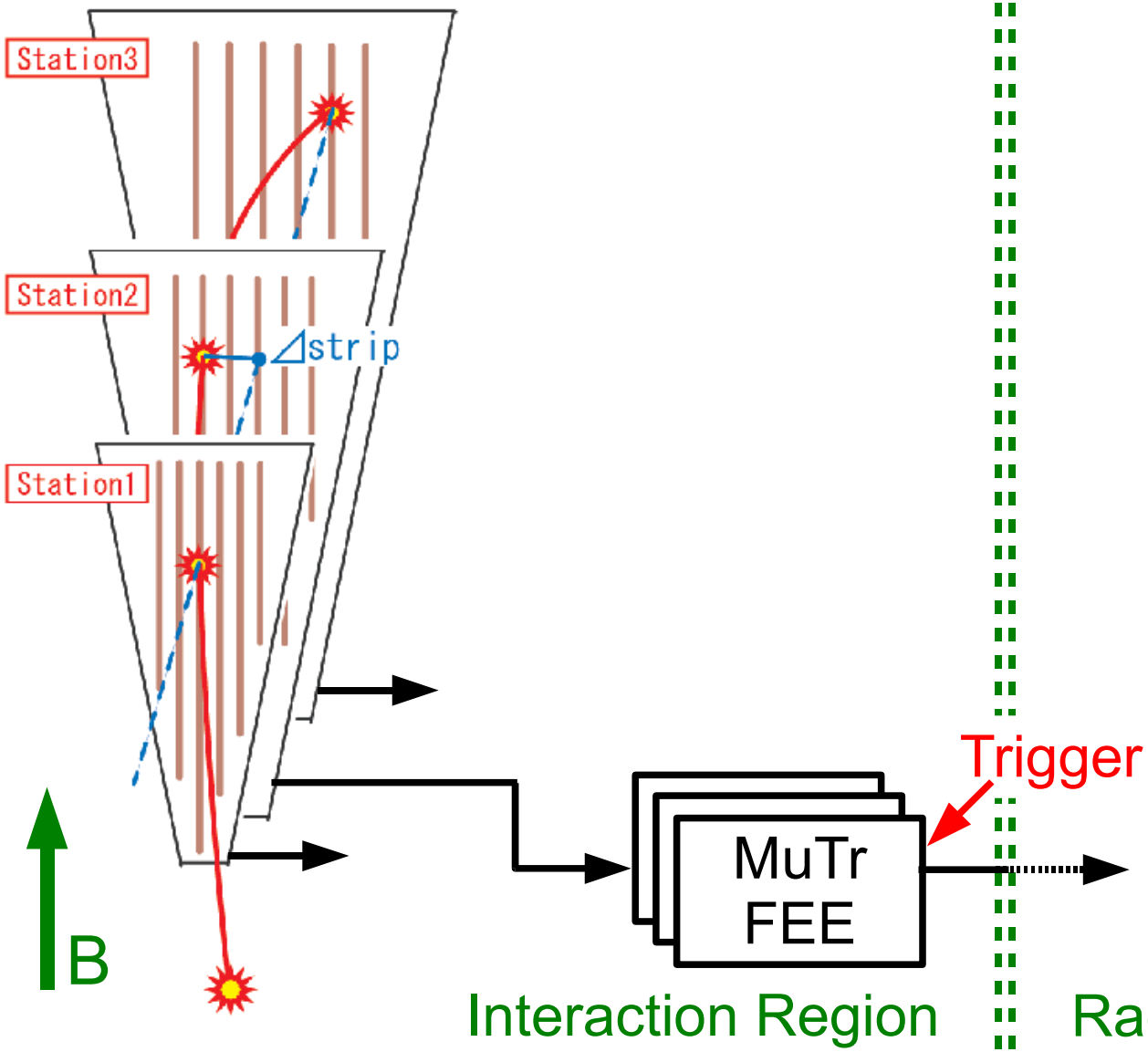
Fast online tracking and select straight track

↓

RF of 24000 for pp collision is expected. (simulation)

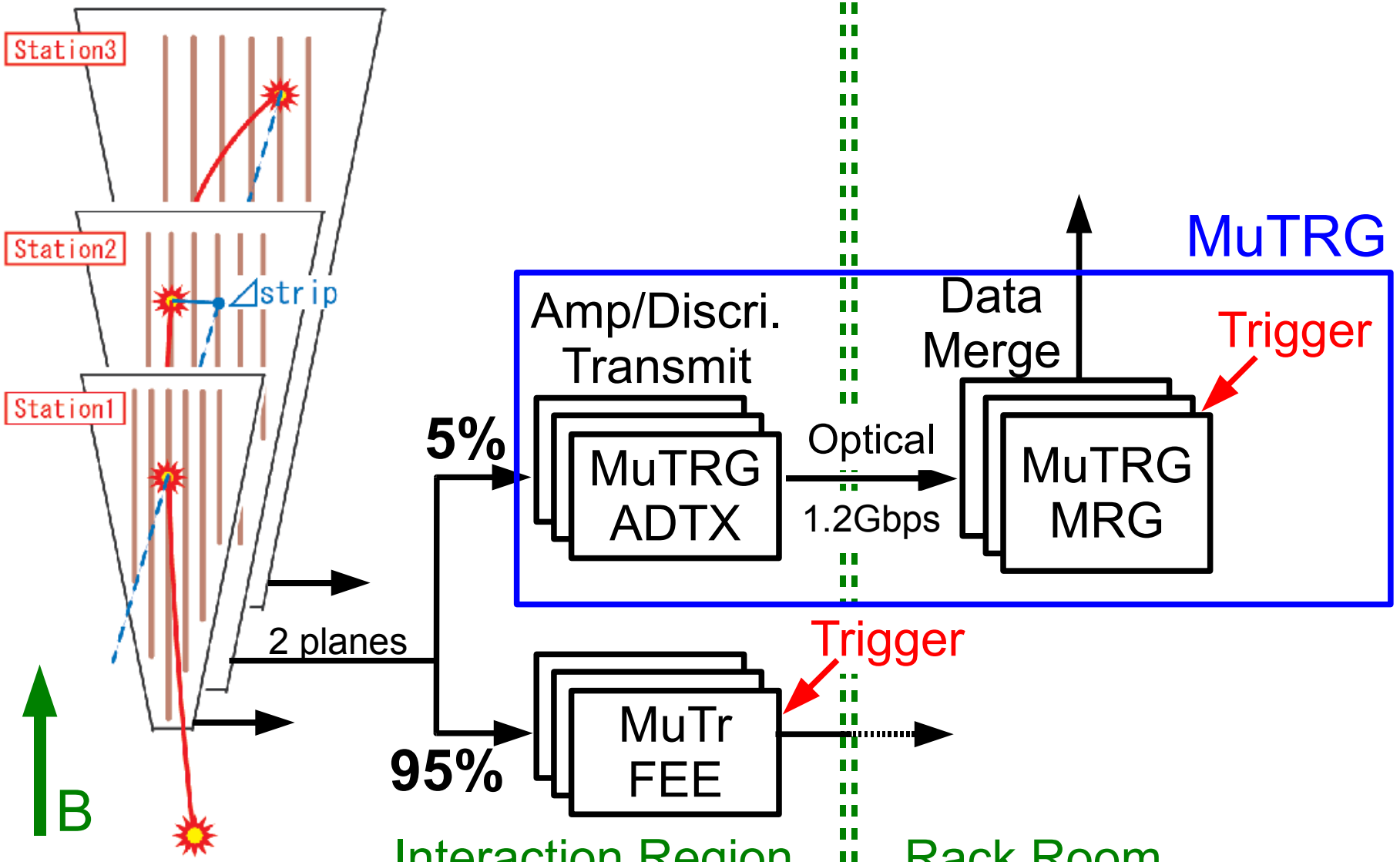
W Trigger System

Trigger events with straight track
(e.g. Δstrip <= 1)



W Trigger System

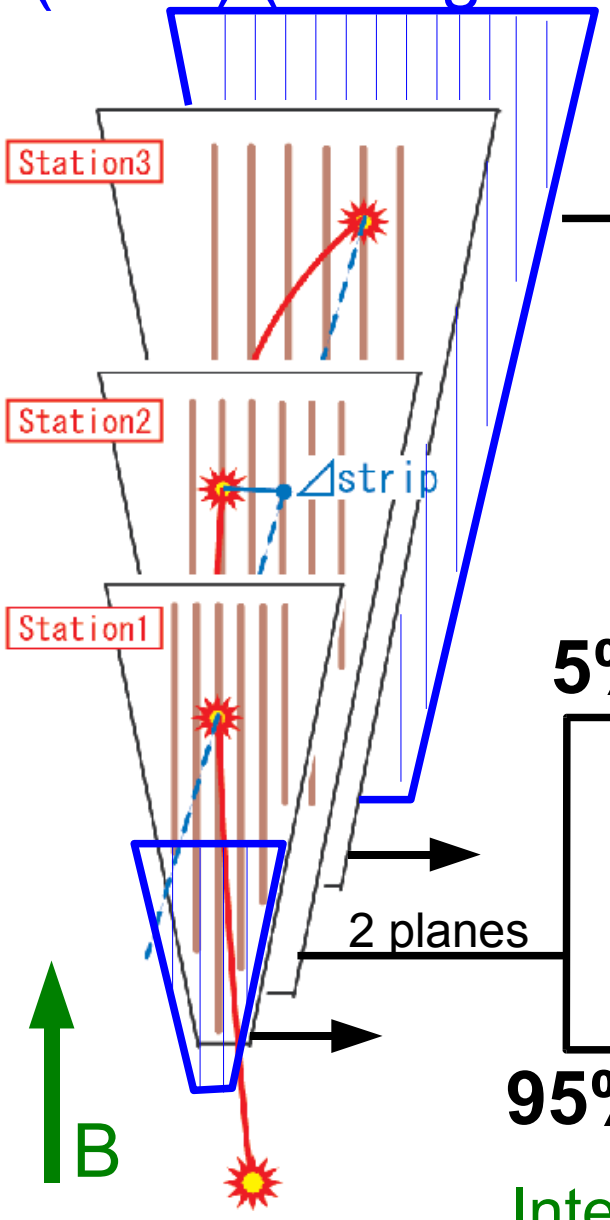
Trigger events with straight track
(e.g. Δstrip <= 1)



W Trigger System

Resistive Plate Counter (RPC) (Φ segmented)

Trigger events with straight track (e.g. Δstrip <= 1)



RPC FEE

MuTRG

Amp/Discri. Transmit

Data Merge

Trigger

5%

MuTRG ADTX

Optical

1.2Gbps

MuTRG MRG

2 planes

Trigger

95%

MuTr FEE

B

RPC / MuTRG data are also recorded on disk.

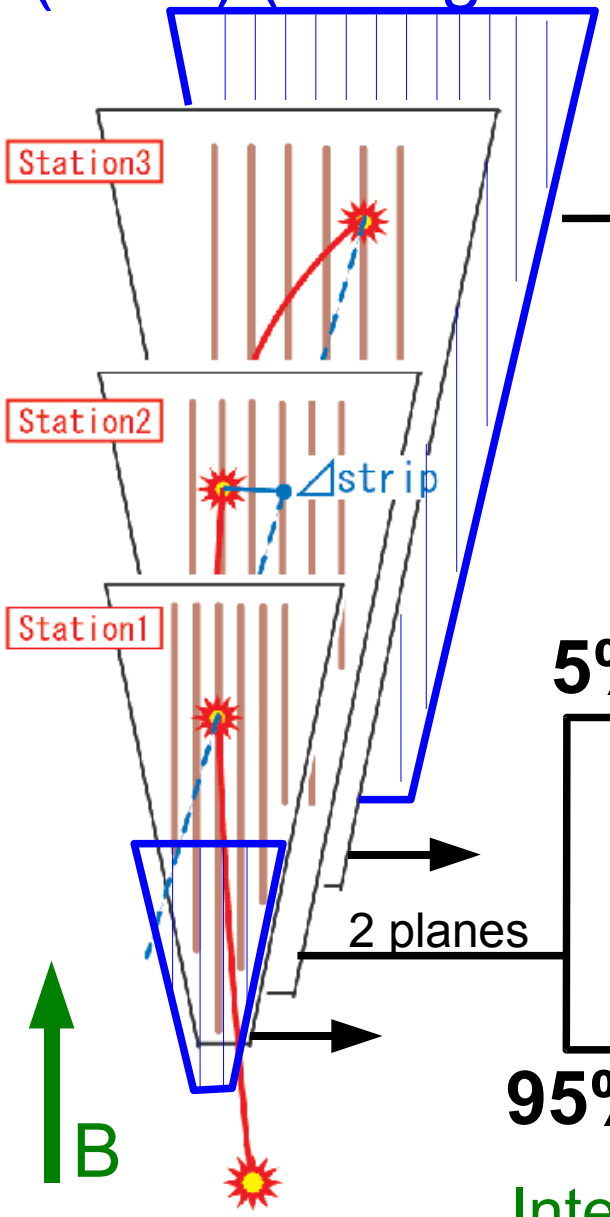
Interaction Region

Rack Room

W Trigger System

Resistive Plate Counter (RPC) (Φ segmented)

Trigger events with straight track (e.g. Δstrip <= 1)



RPC FEE

Level 1 Trigger Board

Trigger

MuTRG

Amp/Discri. Transmit

Data Merge

Trigger

5%

MuTRG ADTX

Optical

1.2Gbps

MuTRG MRG

Trigger

95%

MuTr FEE

RPC / MuTRG data are also recorded on disk.

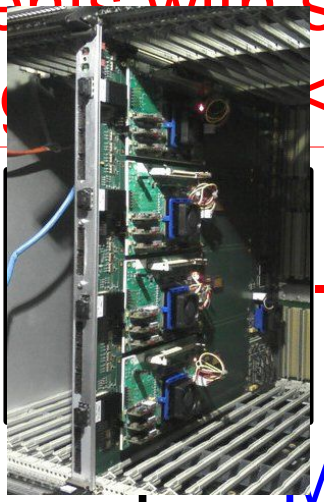
Interaction Region

Rack Room

W Trigger System

Resistive Plate Counter
(RPC) (Φ segmented)

Trigger events with straight track
(e.g. <= 1)



Trigger

RPC
FEE

MuTRG

Station3

Station2

strip

Station1

Amp/Discri.

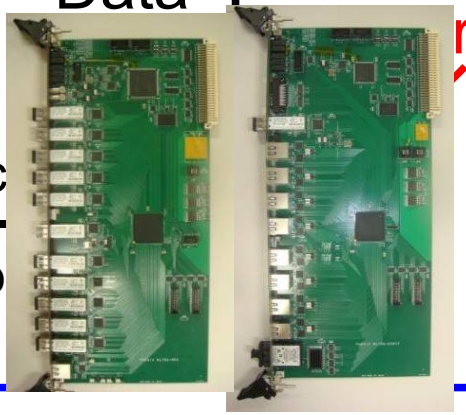
Data

rigger

5%

ptic

2Gb



2 planes

Trigger

95%

MuTr
FEE

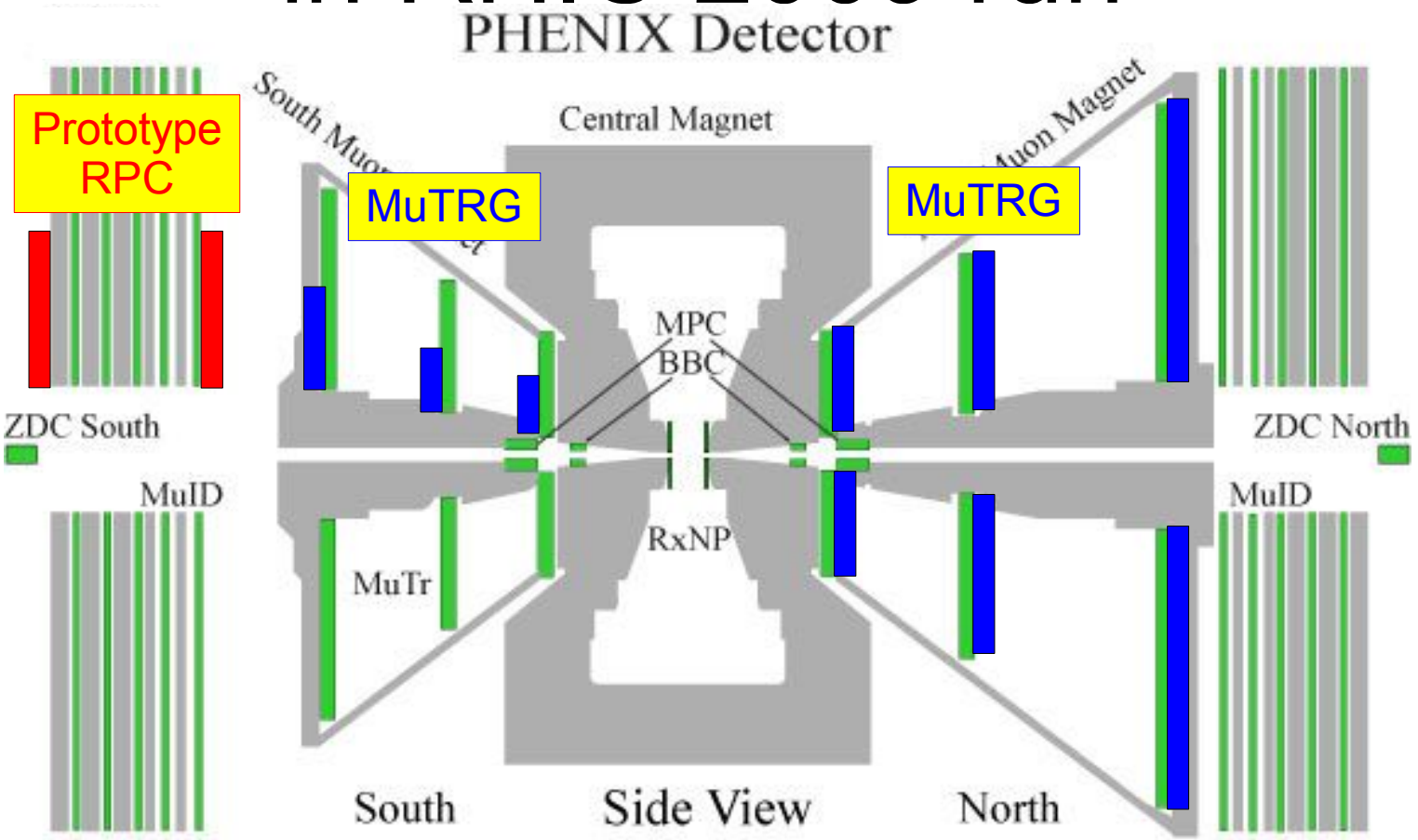
RPC / MuTRG data are
also recorded on disk.

B

Interaction Region

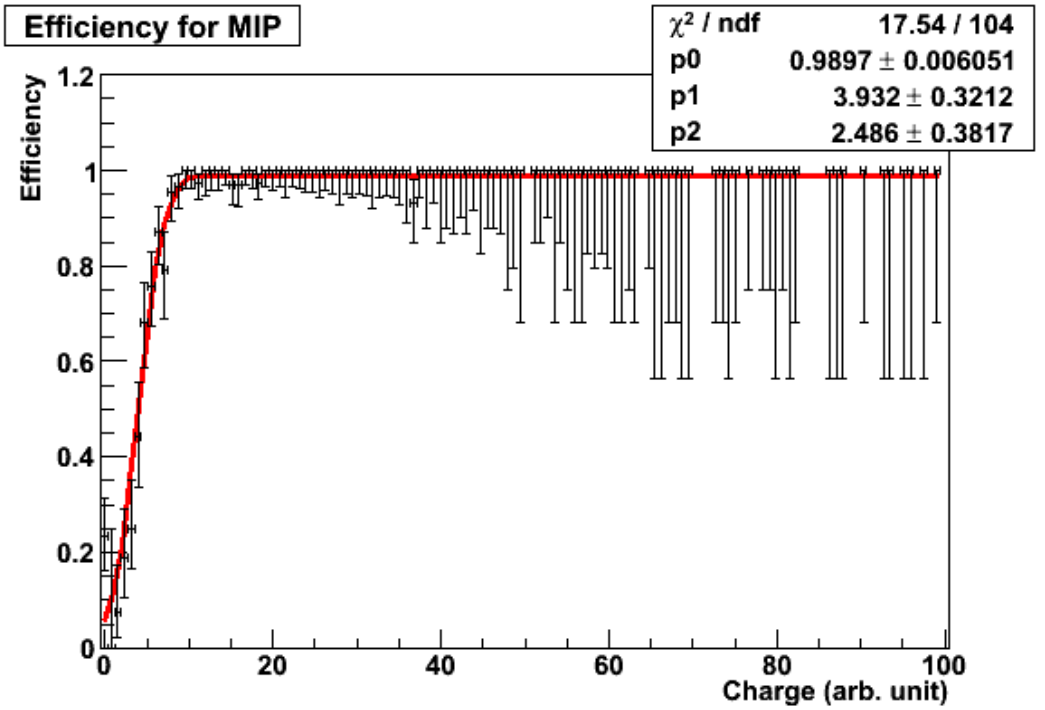
Rack Room

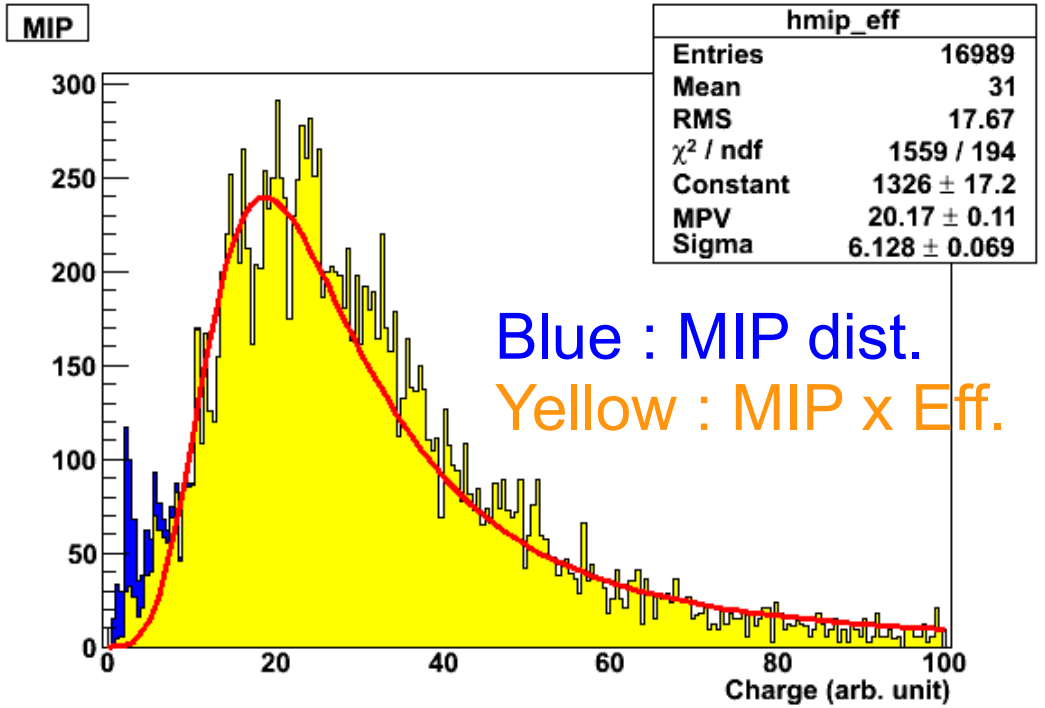
W Trigger Instrumentation in RHIC 2009 run



- MuTRG was installed fully in north arm and partially in south arm.
- Prototype RPC was installed partially in south arm.
- Evaluate performance of RPC and MuTRG with beam of $\sqrt{s}$=500 GeV.

Efficiency for MIP (MuTRG)





Efficiency ~ 100%
at Plateau

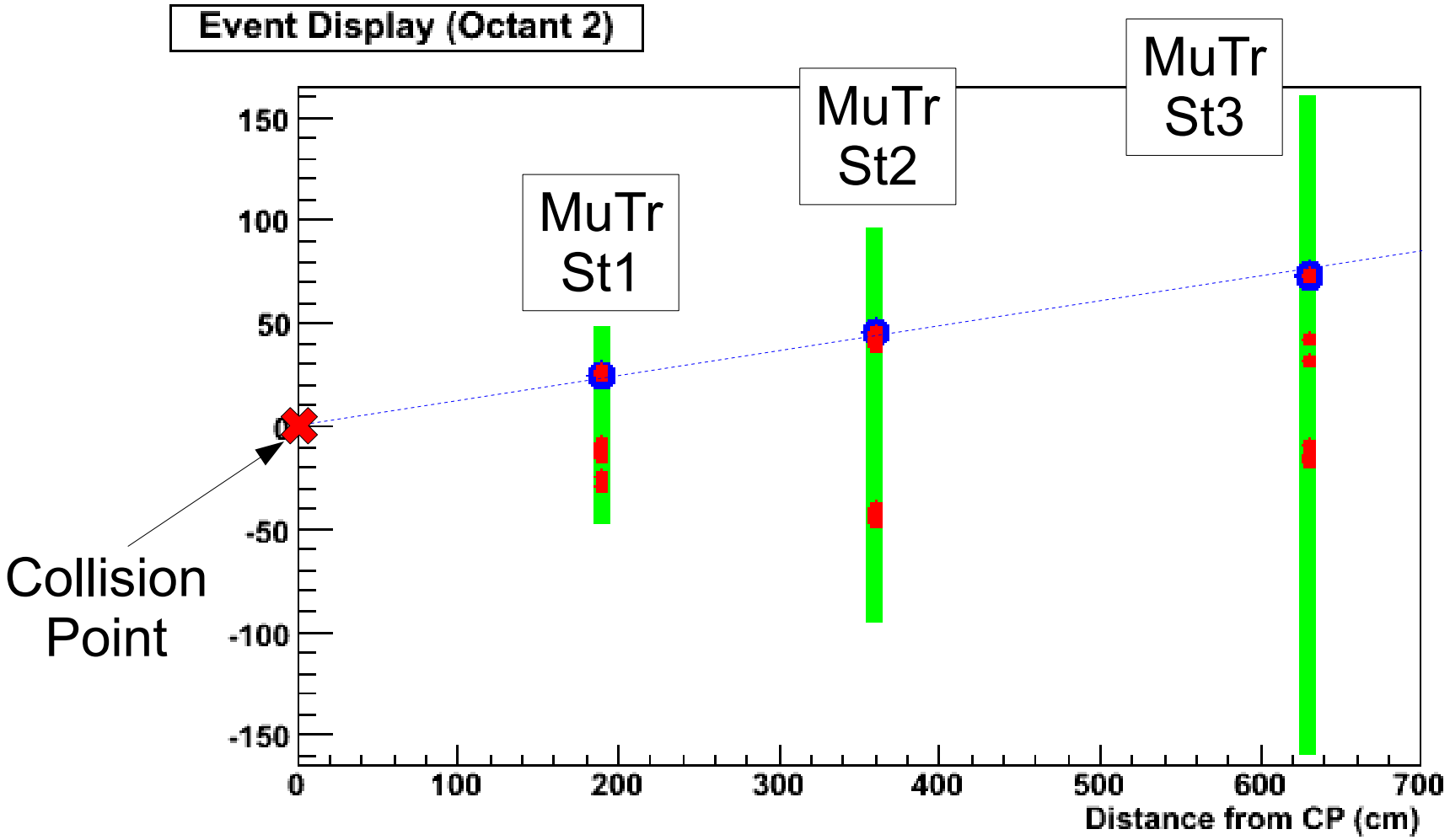
Turn on Point of
Efficiency Curve ~ 4

Most Probable Value
of MIP ~ 20

MuTRG and MuTr have matching properly.

Efficiency for MIP is 97.5% (Yellow / Blue)

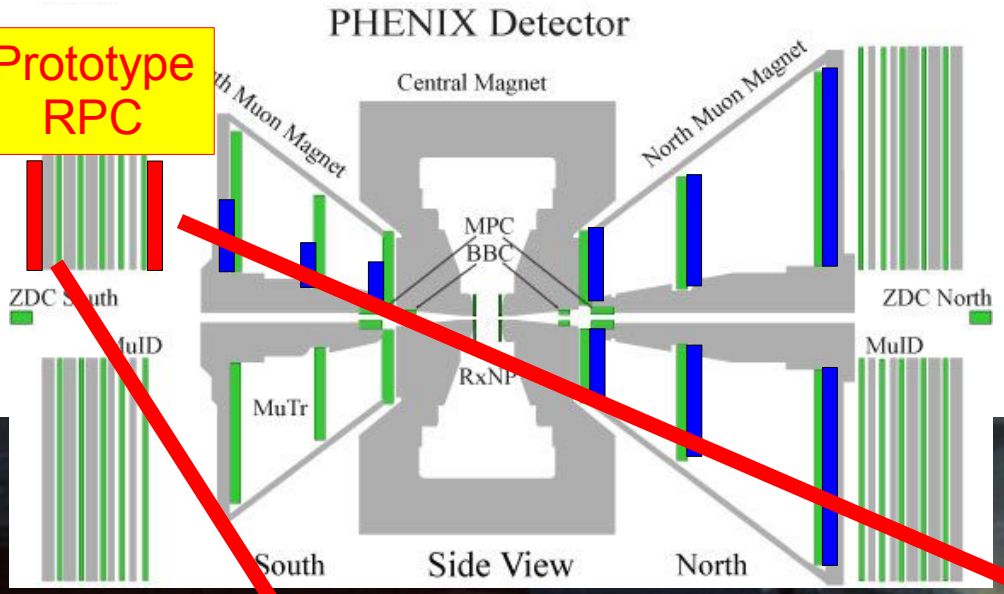
Trigger Emulation in Offline Analysis (only MuTRG)

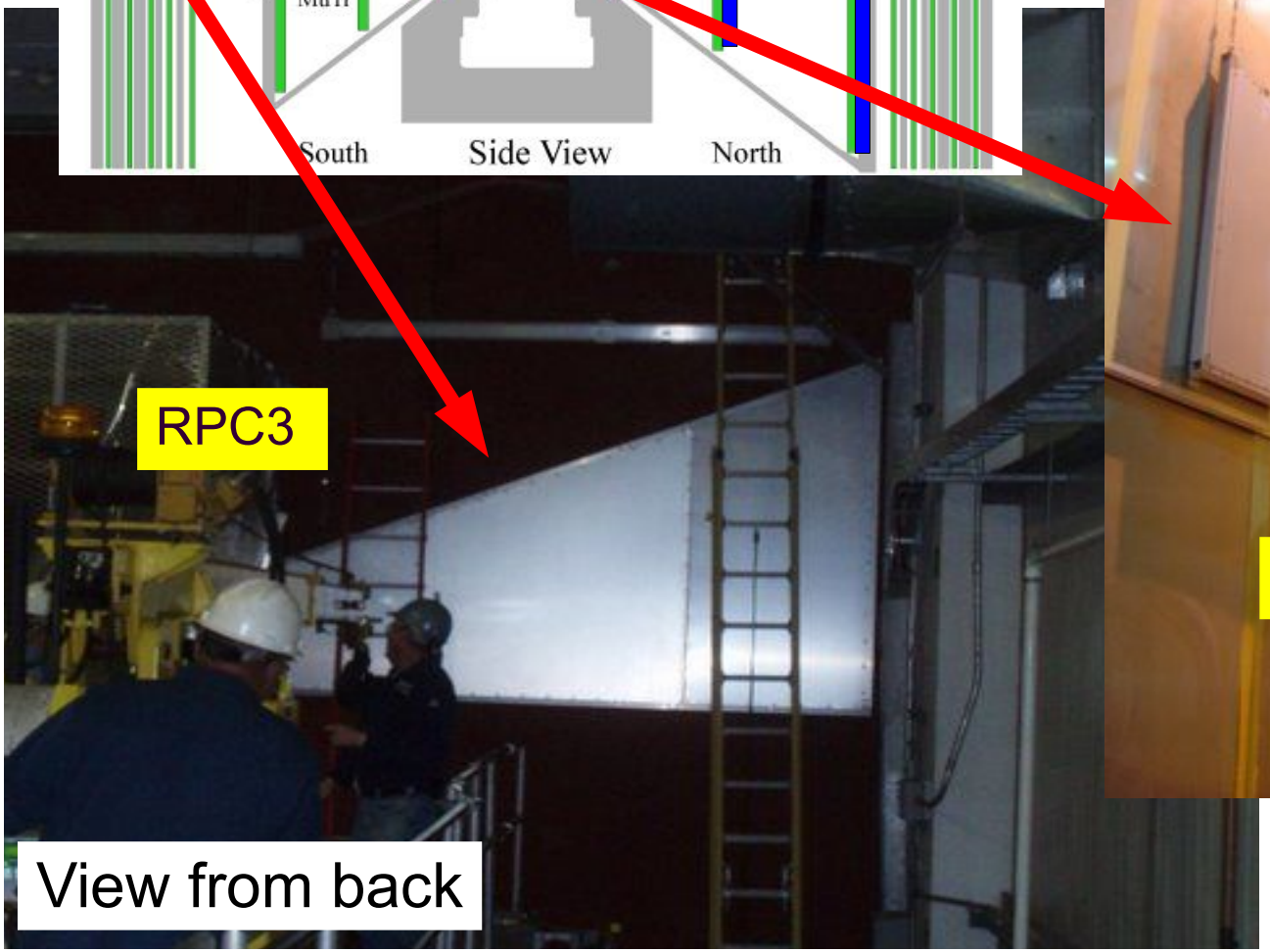


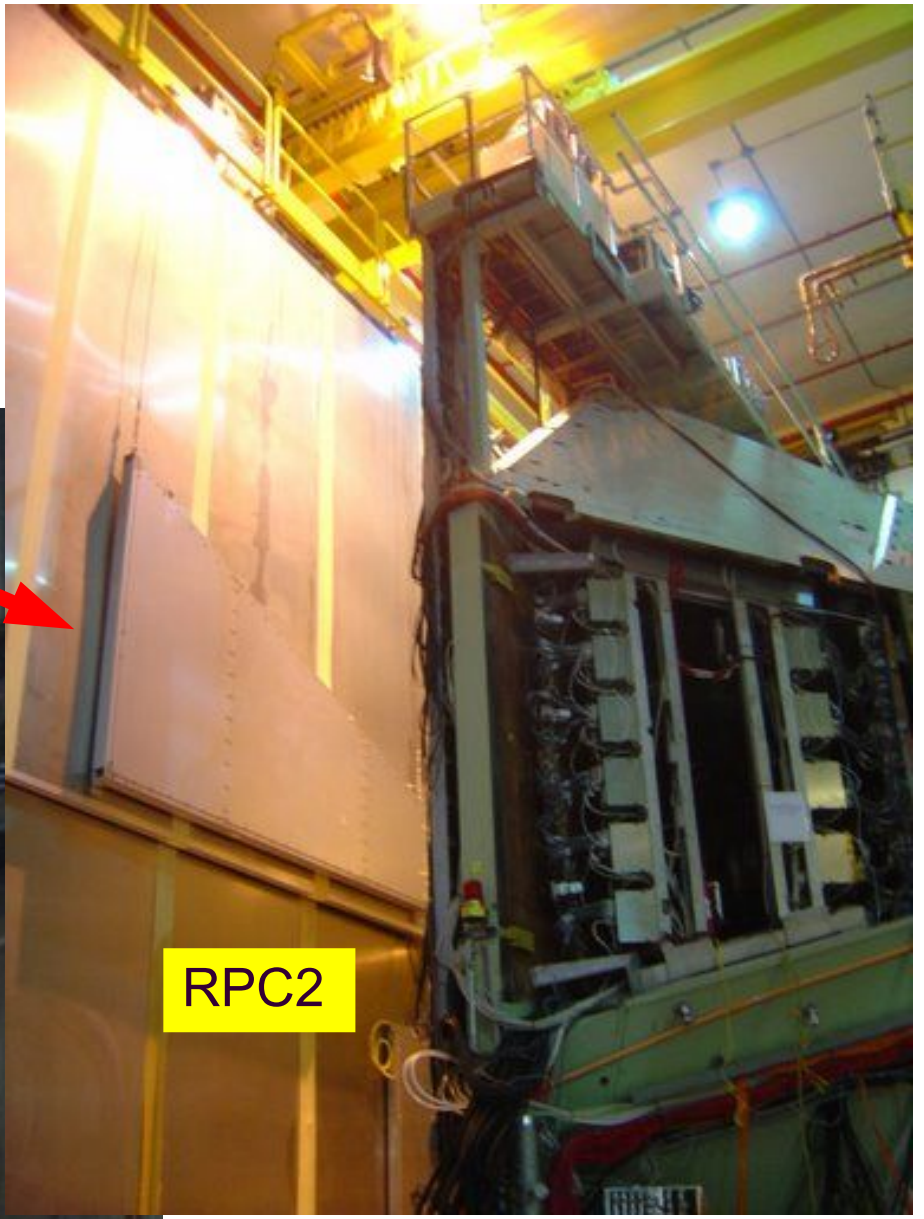
Red : MuTRG Hit, Blue : Accepted Track

Study of rejection power is ongoing in offline analysis.

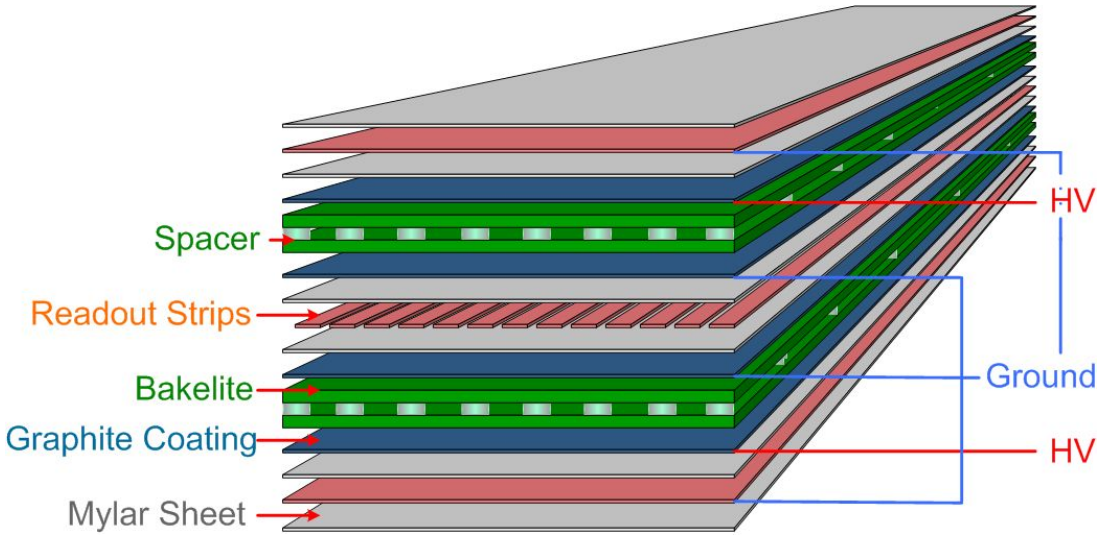
Prototype RPC installed in 2009 run

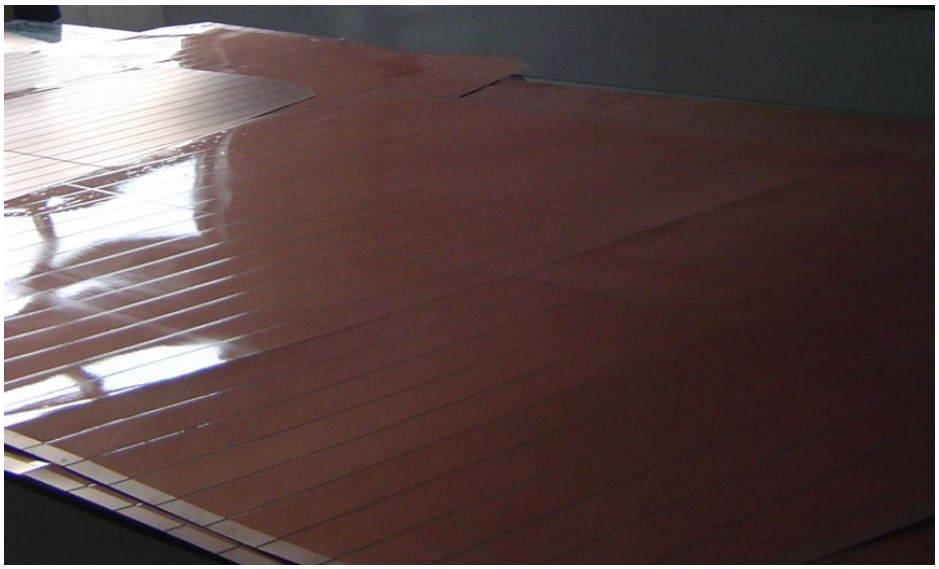






RPC





PHENIX RPC picked LHC-CMS technology

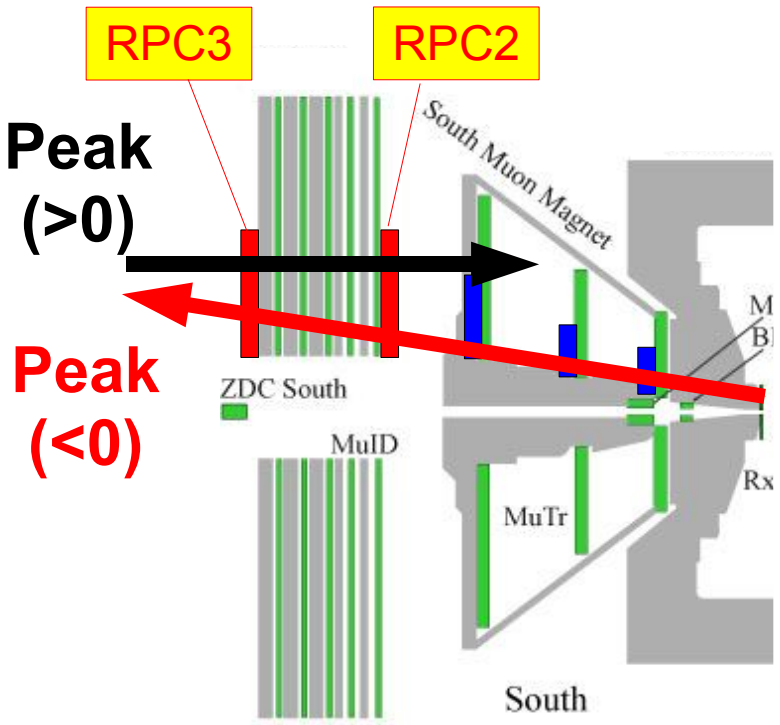
Readout strips are segmented (~1 degree in Φ angle)

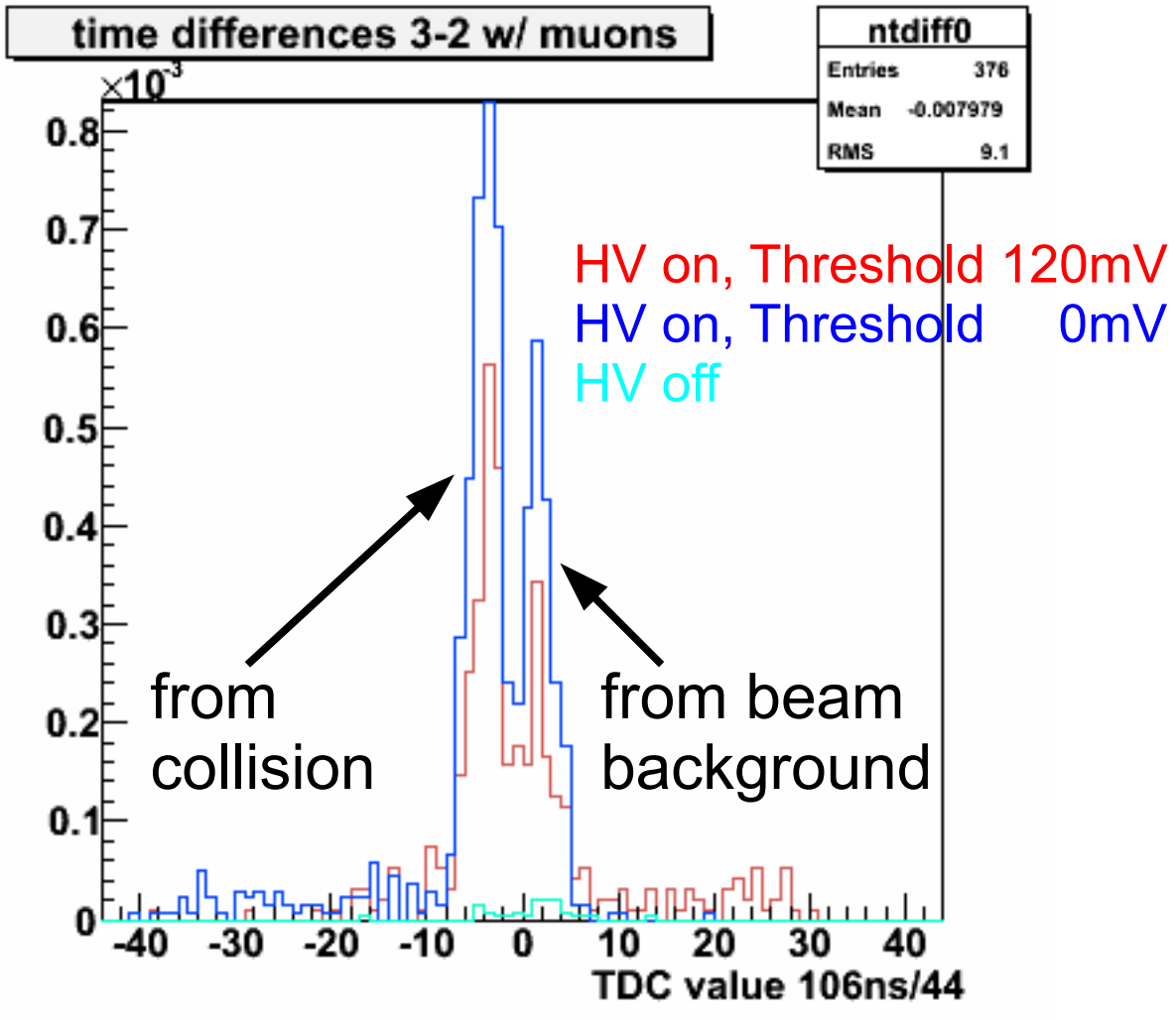
RPC Feature

- Fast Response
- **Good Time Resolution : 1-2 ns**
- Good Spacial Resolution : ~cm
- Small Cluster Size
- High Rate Capability

RPC meets W trigger requirement

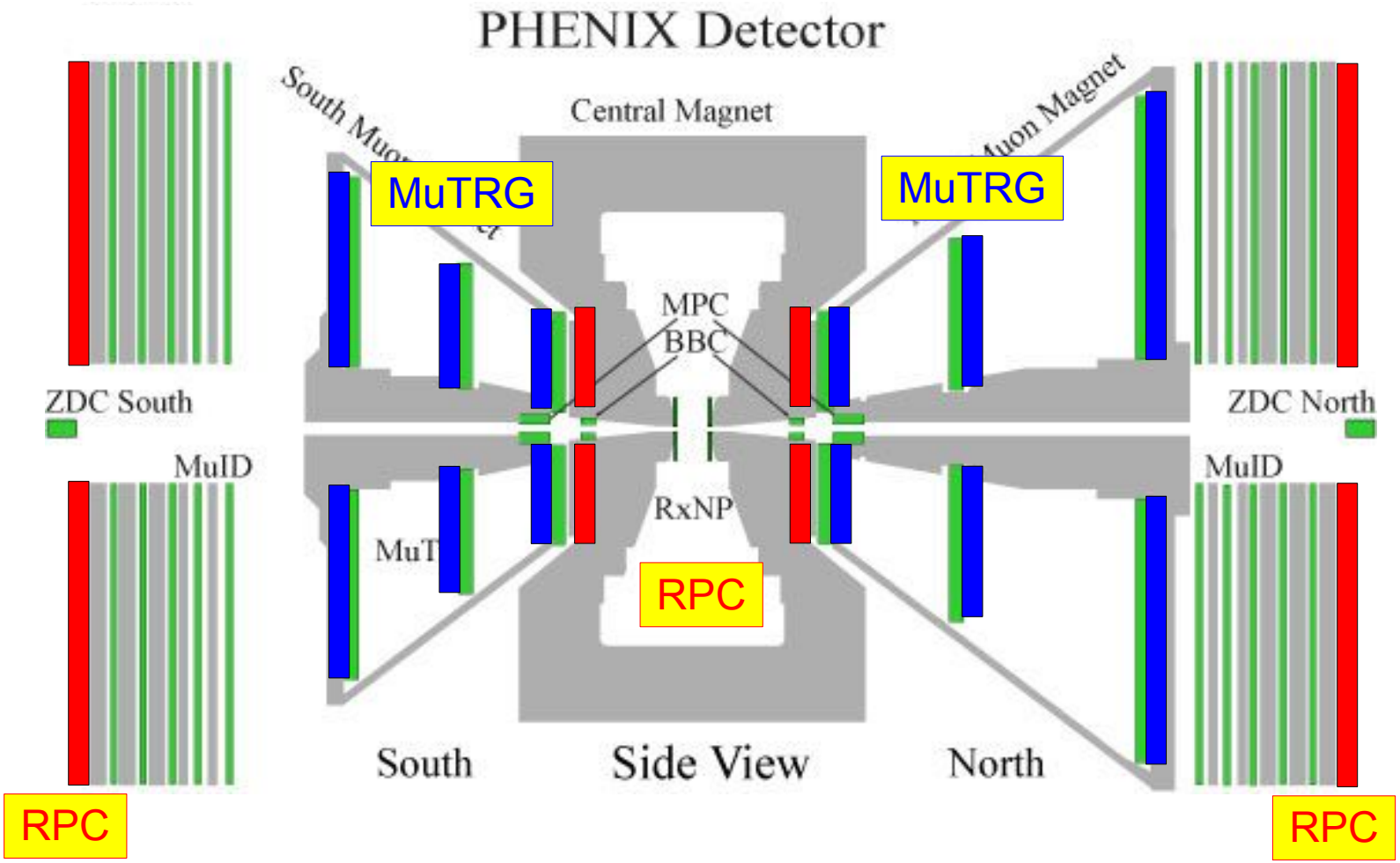
Prototype RPC Timing Distribution





Peak (<0) : Tracks coming from collision or outgoing beam.
Peak (>0) : Background by incoming beam.
Width of each peak : 3ns

Final W Trigger Instrumentation



Installation of RPC and MuTRG will complete by 2010 and they are ready for the next 500 GeV run.

Summary

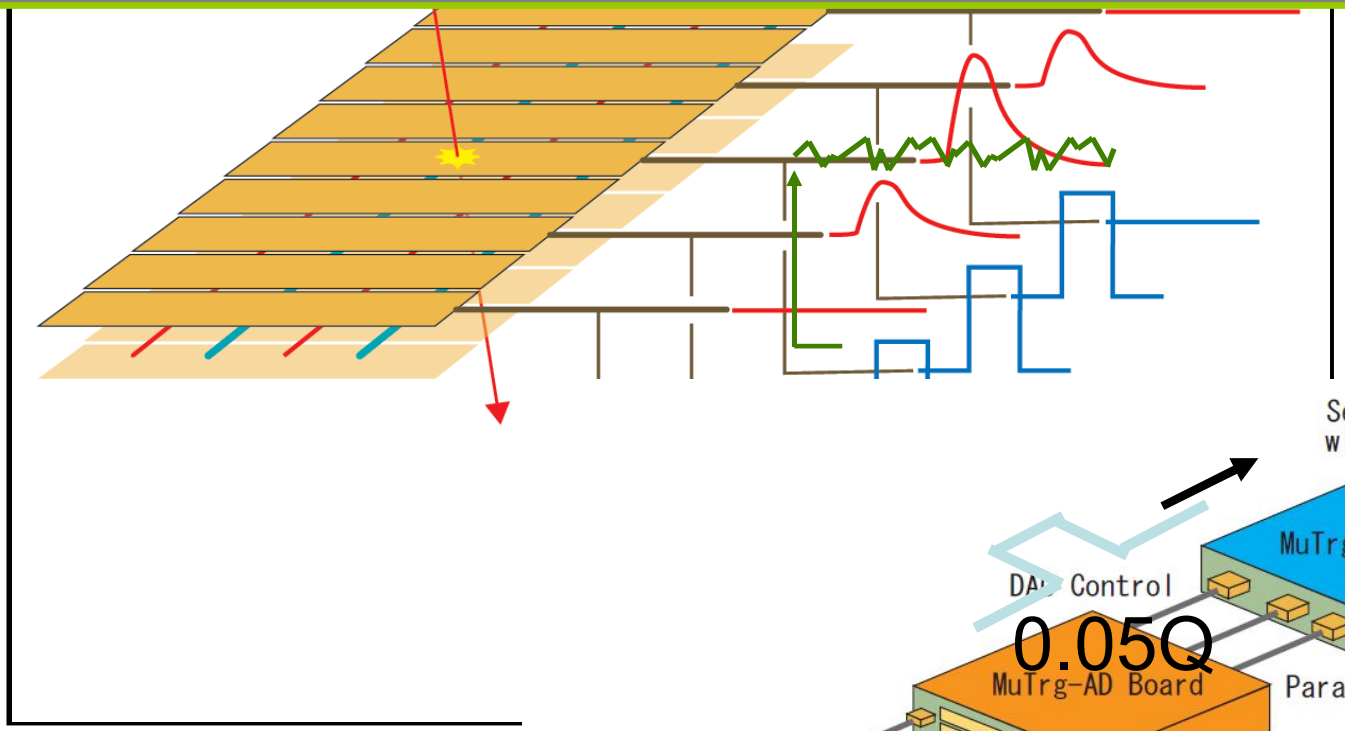
- PHENIX upgrades forward W trigger (RPC + MuTRG) to study sea quark polarization in proton.
- Development of RPC and MuTRG is ongoing. A part of detectors were installed during shutdown period in 2008.
- RHIC operated 500GeV pp run in 2009. RPC and MuTRG took data and we evaluate performance of the detector.
- Installation of RPC and MuTRG will complete by the next physics run with 500 GeV.

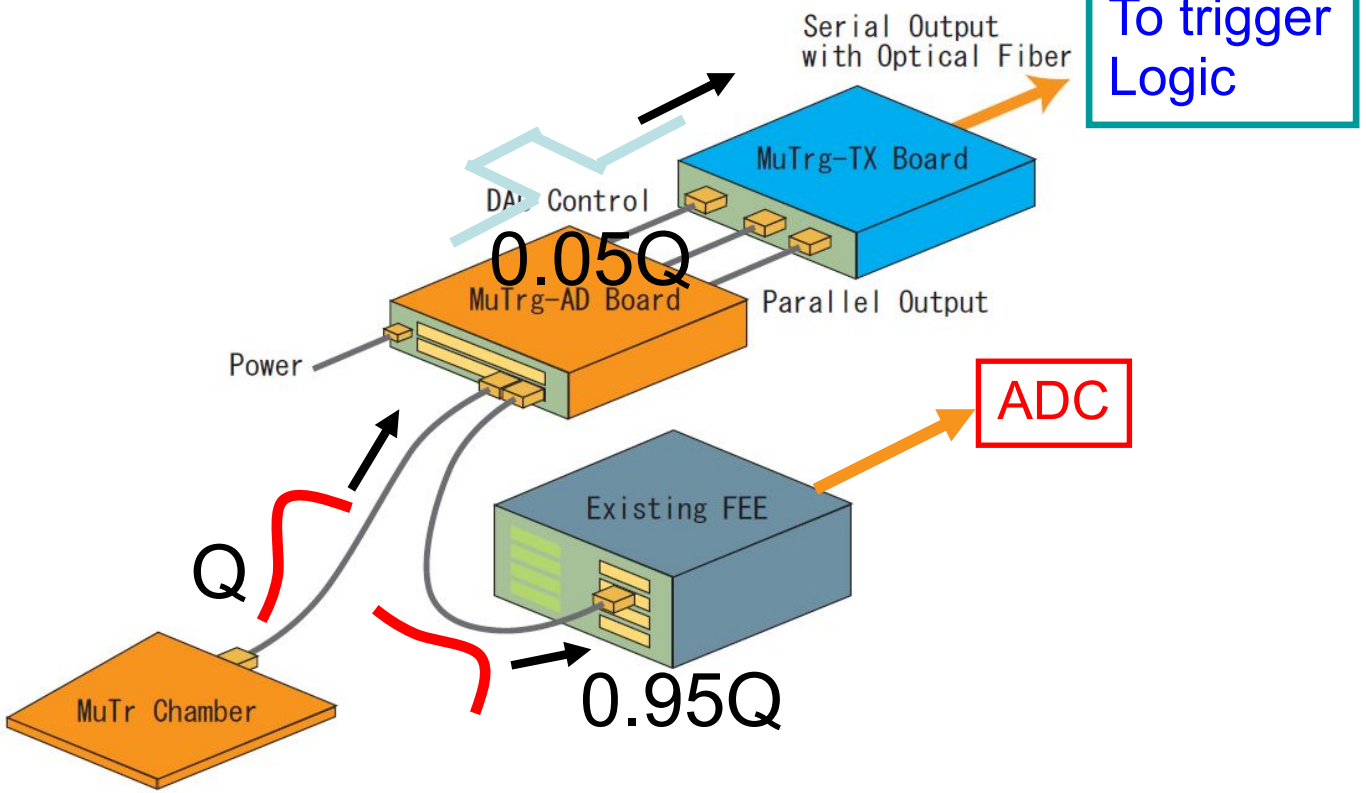
Back Up

1. Minimum deterioration to existing MuTR performance

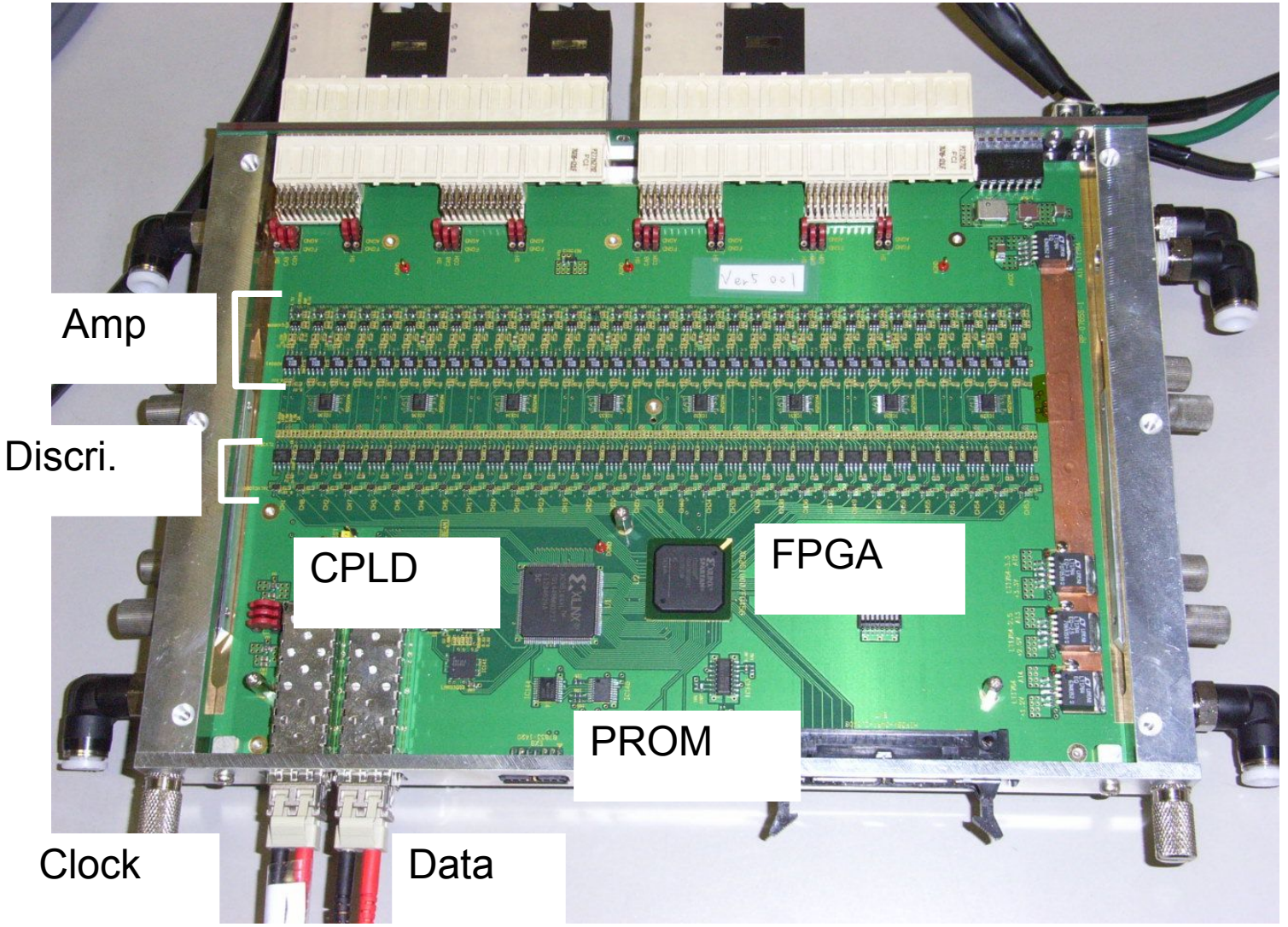
1. High/reliable triggering efficiency

Bottom Line

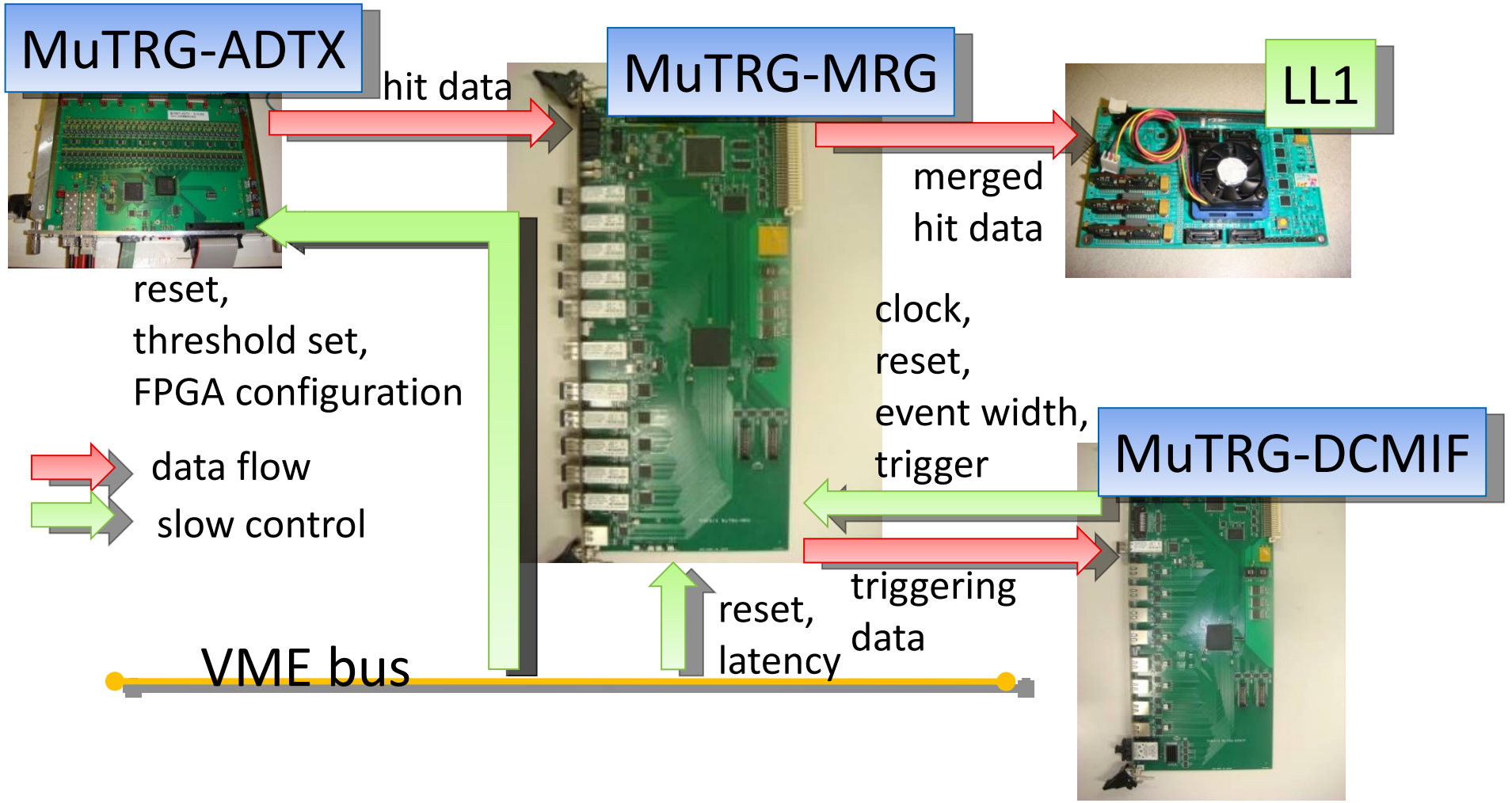




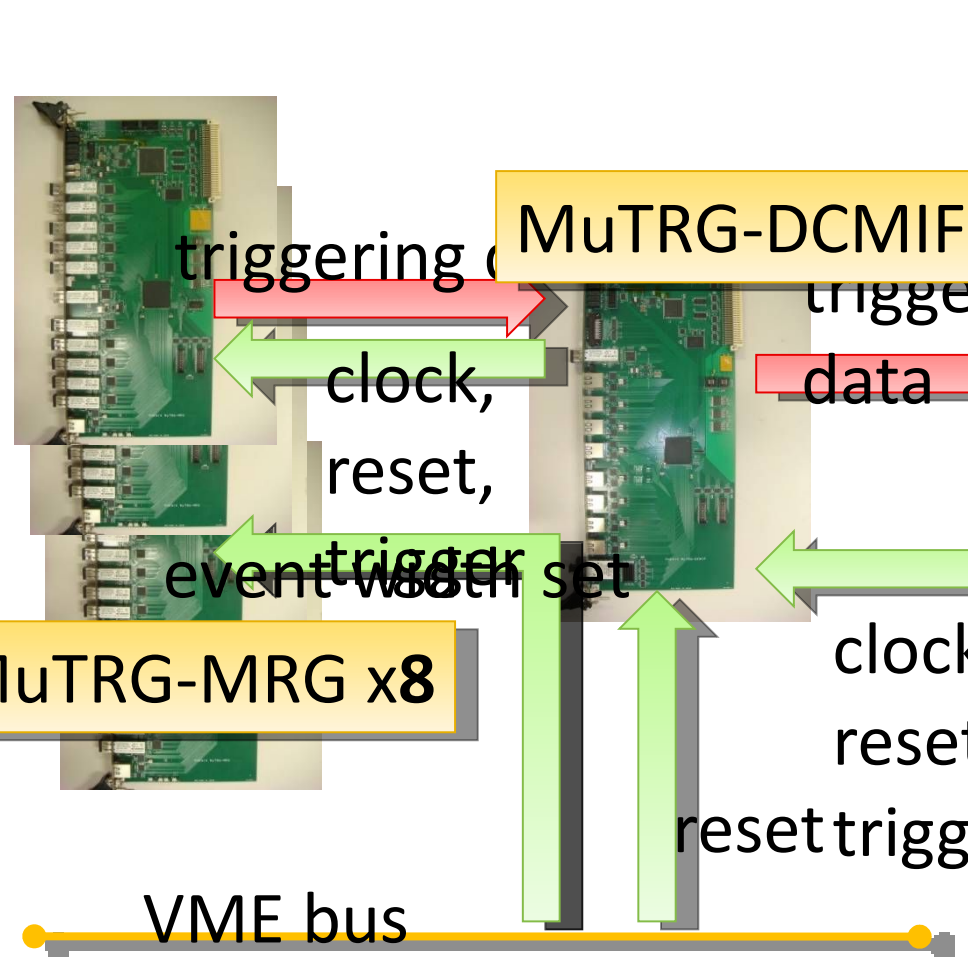
MuTRG-FEE (ADTX)



MuTRG-FEE (MRG and DCMIF)

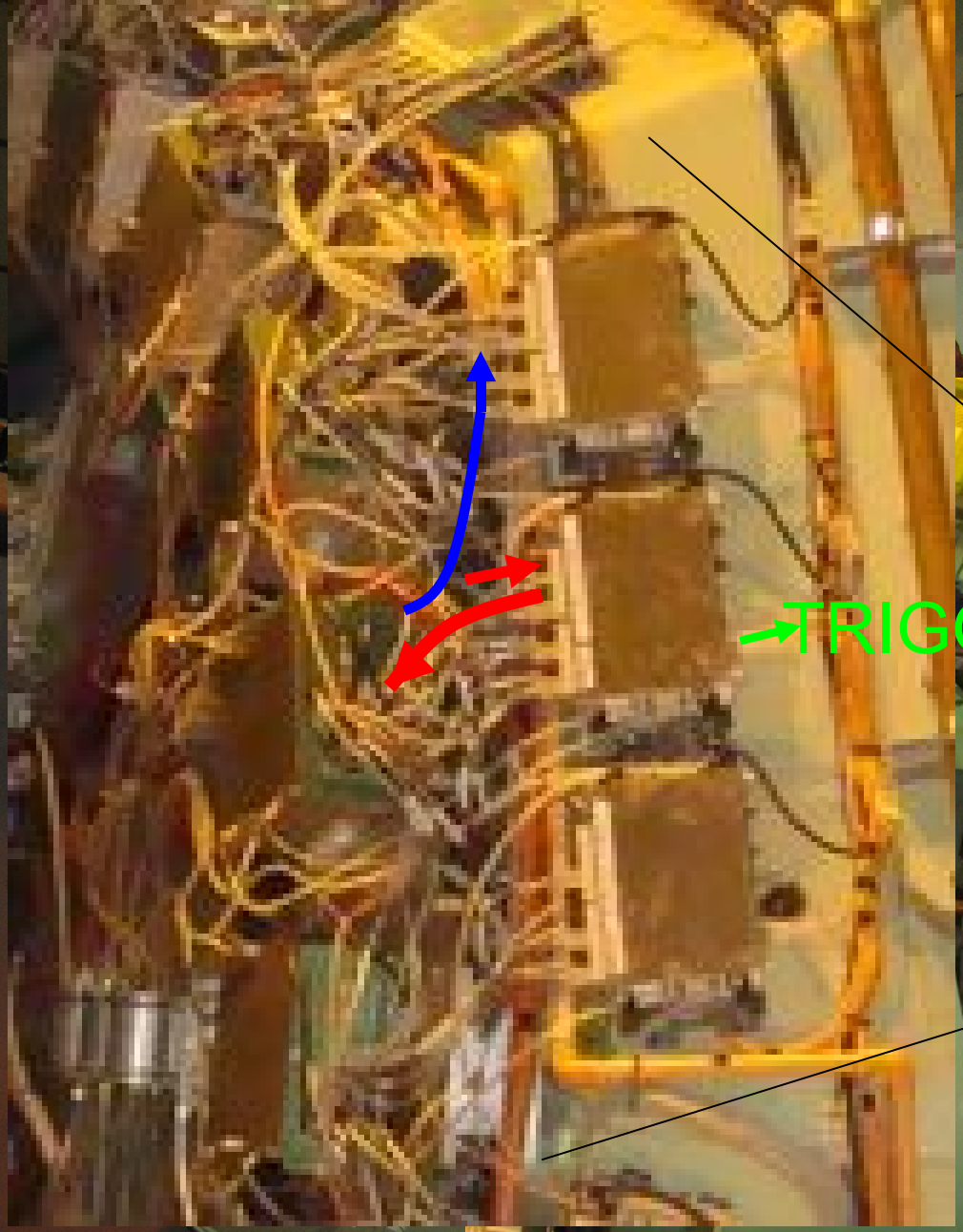


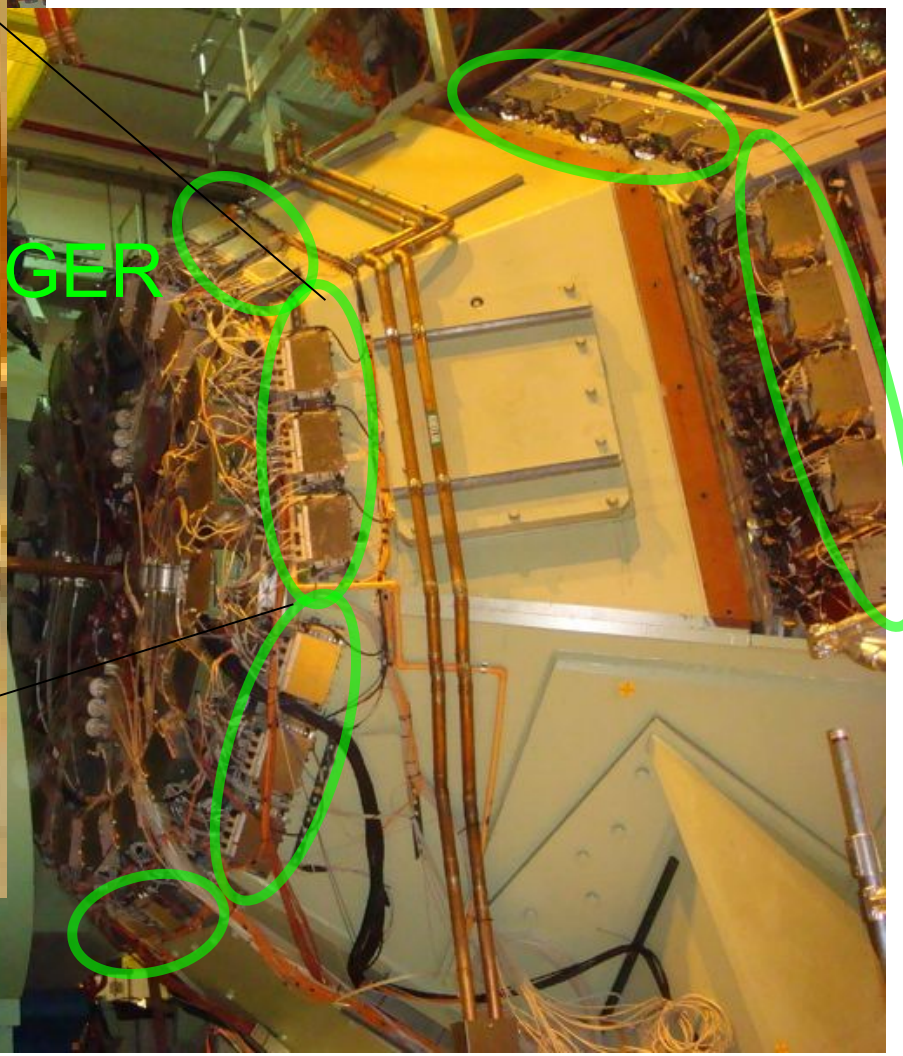
the roles of MuTRG-DCMIF

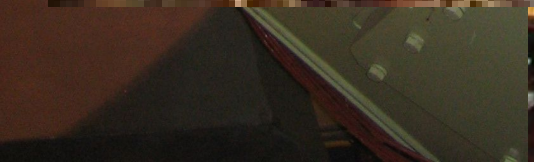


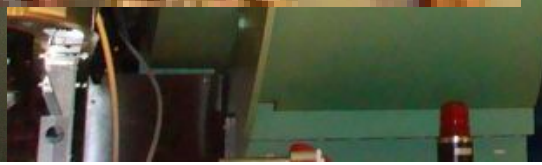
- one DCMIF board handles 8 MRG boards
- merge triggering data from MRG and send it to DCM
- distribute GTM signal (clock, reset, trigger) to MRG

all Status

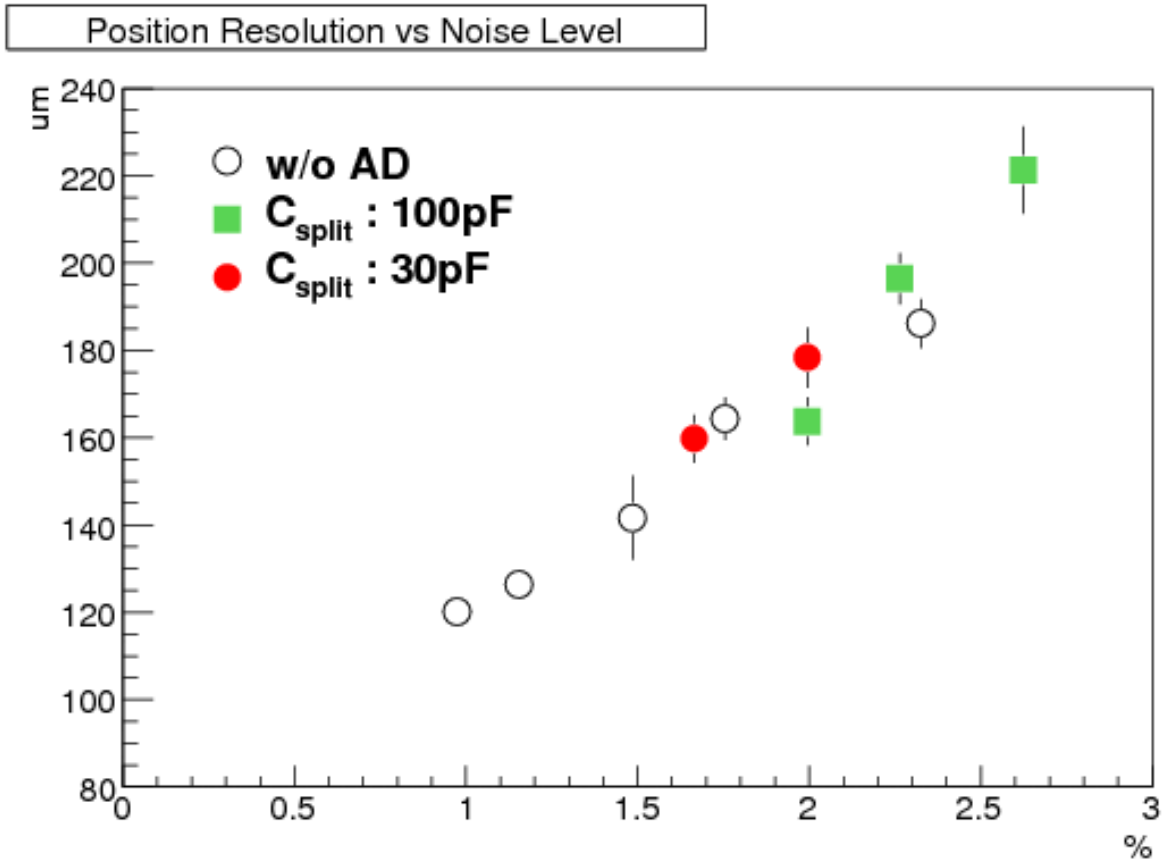








Noise Level to Position Resolution



Correlation between noise level and position resolution was observed in test experiment at Tohoku Univ. (Uncertainty of reference track ~50um)

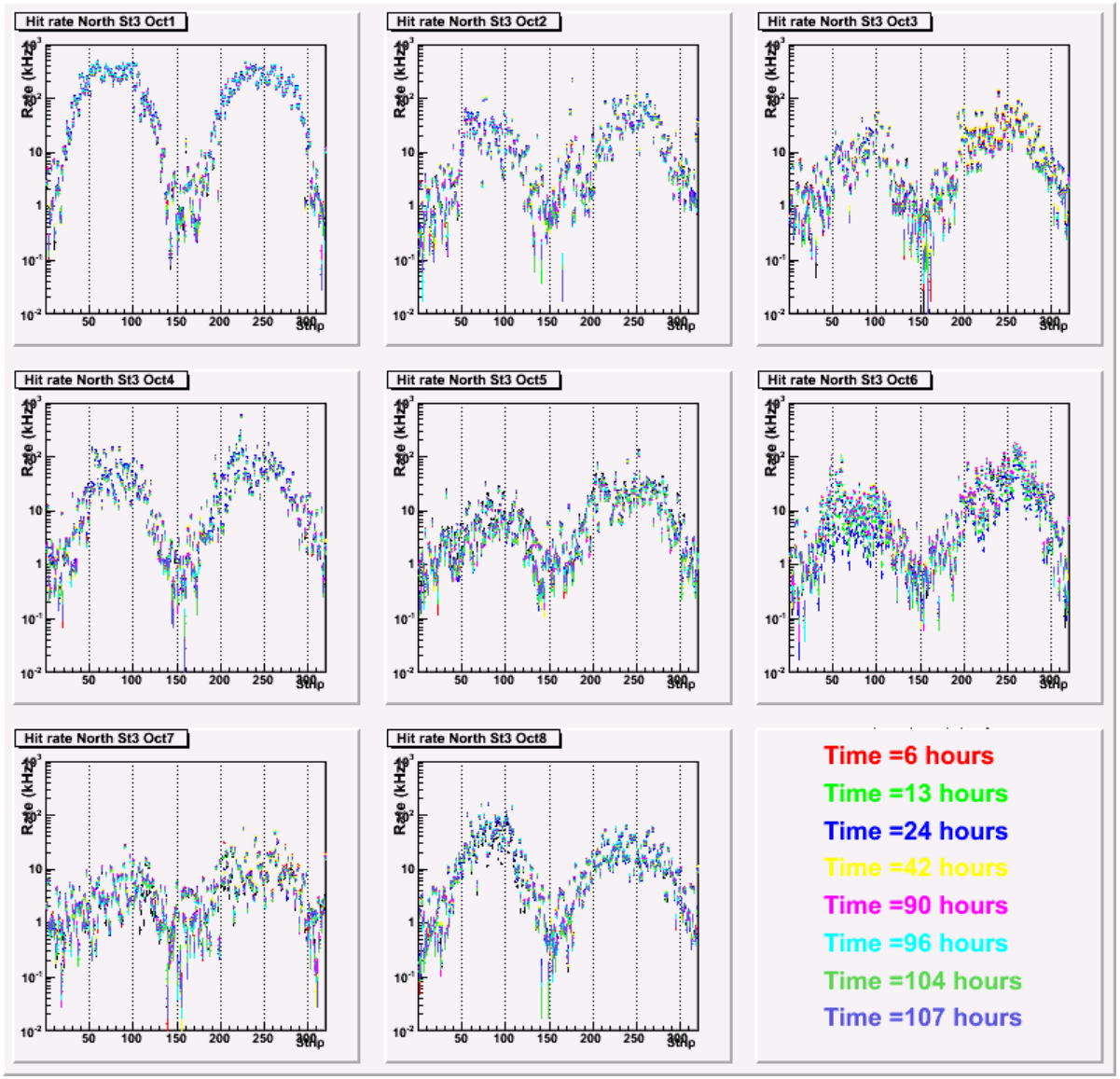
	Noise Level	Position Resolution
St1	1.2%	110 um
St2	1.3%	120 um
St2(HV+25V)	1.0%	100 um

Degradation of position resolution is acceptable.

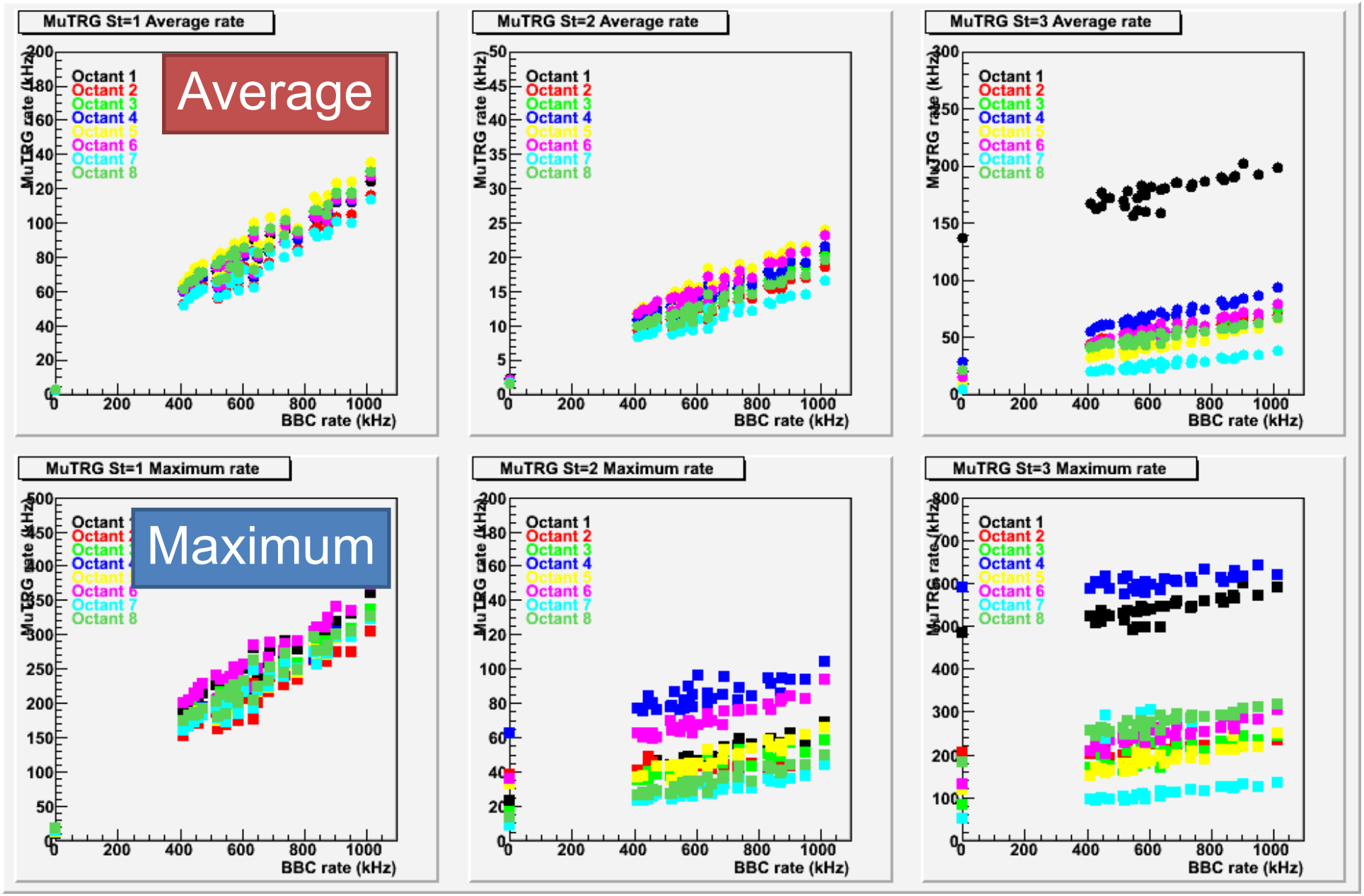
Design value is achieved by raising HV by 25V.

Fake hit rate (beam-off, 20 mV)

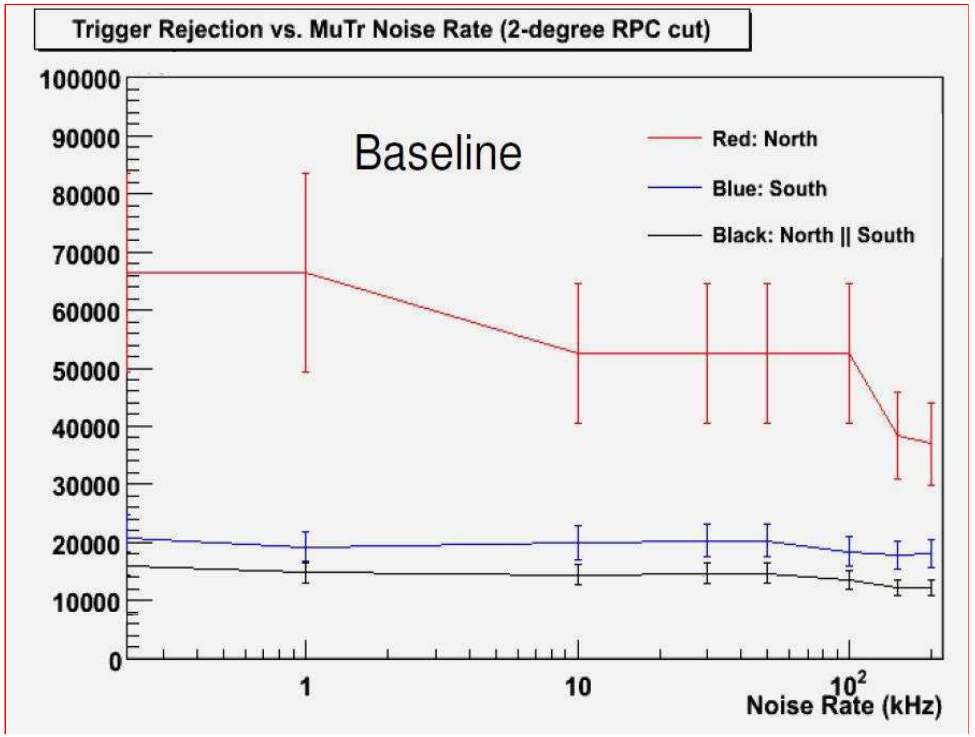
- The fake hit rate is typically 1-10k Hz
- Larger (~100k Hz) at N.St1.Oct1
- The fake hit rate is stable over a month.



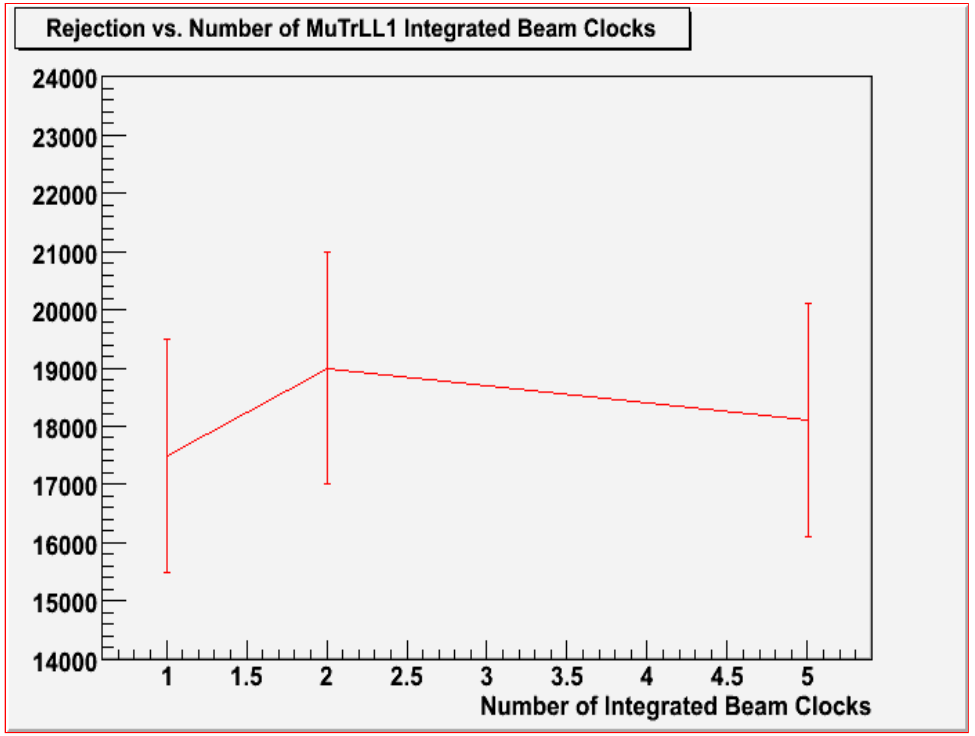
MuTRG single rates / strip (20 mV)



シミュレーション



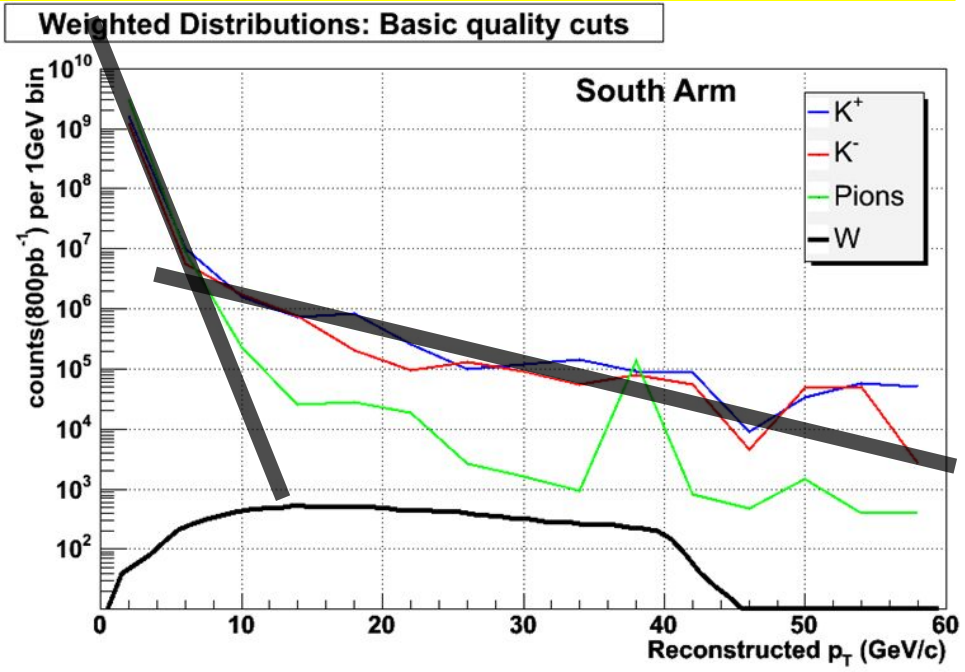
Fake Hite Rateと
棄却能力

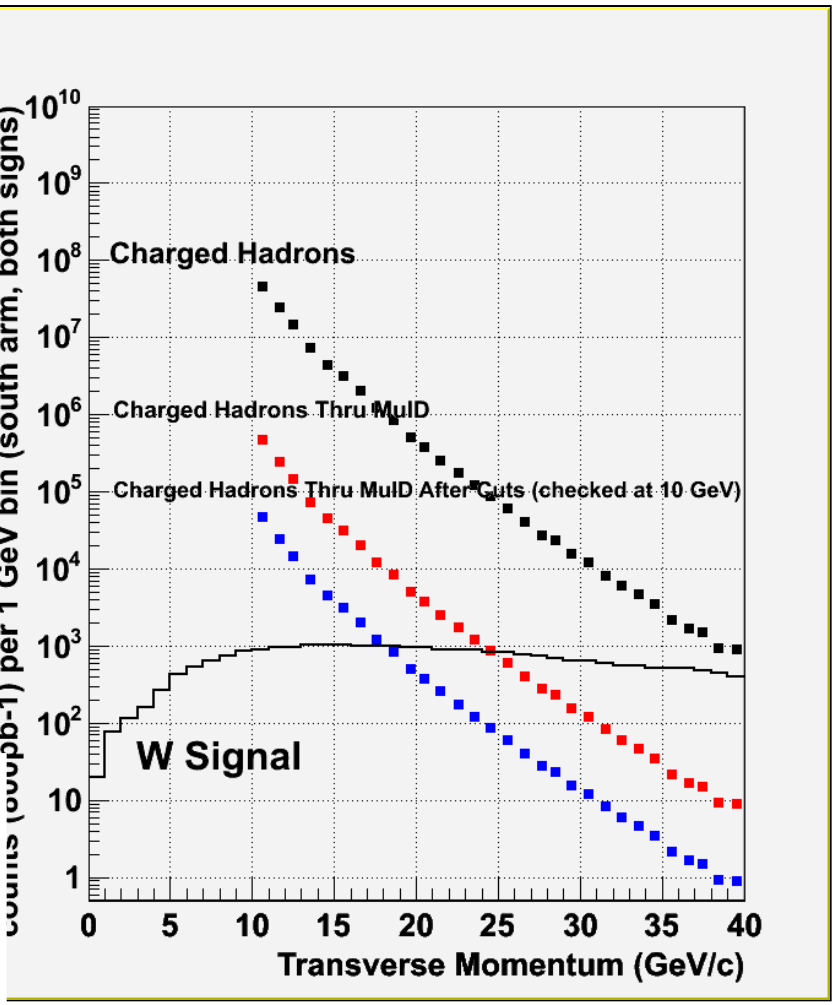


トリガーのゲート幅と
棄却能力
（Fake Hit Rate = 1kHz）

Background for W measurement

1. Low PT π,K Decay in Flight 2. Hi P_T π,K punch through





Prima
- *Tracker Alignment*
- *Absober*
- *EM Calorimeter*
- *Etc..*

Future Plan

(Need to ask RPC about updated installation plan)

2008 Run08 : 200GeV pp
MuTRG-FEE North installation

2009 Run09 : 500GeV pp, 200GeV pp
RPC3 South installation
MuTRG-FEE South installation

2010 Run10 : 200GeV Au+Au
RPC1 North & South installation
RPC3 North installation

2011 Run11 : 200GeV U+U

2012 Run12 : 500GeV pp, 200GeV pp

Near Future Run Plan @ RHIC

2003 ~ 2008 : sqrt(s)=200 GeV

Tentative RHIC Run Plan Following 2008 PAC Recommendations
(assumes 6-month CR in FY09, then FY10-14 budgets sufficient to support 2-species runs each year; incorporates best available information on detector upgrade schedules as of 6/20/08)

Fiscal Year	Colliding Beam Species/Energy	Comments
2009	500 GeV p+p	Assuming ~April 1 start, about 5-6 physics weeks to commission collisions, work on polarization & luminosity and obtain first W production signal to meet RIKEN milestone
2010	200 GeV p+p	~12 physics weeks to com could be swapped with 50 March 1, 2009; STAR DA
	200 GeV Au+Au	9-10 physics weeks with P TOF permits low-mass dil test of transverse stochasti
2011	Au+Au at assorted low E	1st energy scan for critical luminosity improvement – decided; commission PHE
	200 GeV U+U	1st U+U run with EBIS, to
2012	500 GeV p+p	1st long 500 GeV p+p run, with PHENIX muon trigger and STAR FGT upgrades, to reach ~100 pb^{-1} for substantial statistics on W production and ΔG measurements
	200 GeV Au+Au	Long production run with full stochastic cooling upgrade implemented, PHENIX VTX and prototype STAR HFT installed; focus on RHIC-II science goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations
2013	500 GeV p+p	Reach ~300 pb^{-1} to address 2013 DOE performance milestone on W production and sea antiquark polarizations
	200 GeV Au+Au or 2nd low-E scan	To be determined by results from 1st low-E scan and 1st upgraded luminosity runs, progress on low-E electron cooling, and on installation/commissioning of PHENIX FVTX and NCC and full STAR HFT
2014	200 GeV Au+Au or 2nd low-E scan	Run option not chosen for 2013 run – low-E scan addresses 2015 DOE milestone on critical point, full-E run addresses 2014 (γ-jet) and 2016 (identified heavy flavor) milestones. Proof of principle test of coherent electron cooling
	200 GeV p+p	Address 2015 DOE performance milestone on transverse SSA for γ-jet; provide reference data for HI runs with new detector subsystems; test electron lenses for p+p beam-beam tune spread reduction